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HUMAN RELATIONS IN INDUSTRY

IN order that the results of action taken concerning human relations in industry during the past few years might be assessed, and that consideration could be given to further steps that should be taken, the Ministry of Labour organized a conference held in London during March 18–20, 1952 (see *Nature*, 169, 872; 1952). The subjects on the agenda were grouped under four headings: (1) factors affecting the opportunity to work; (2) factors affecting the capacity of workers; (3) factors affecting wastage of manpower; (4) factors affecting the will to work. Matters concerning the physical environment, working methods and task organization were omitted.

Papers setting out the situation in each of these groups of subjects, as seen by the Ministry, were circulated in advance to the four hundred delegates who attended the conference. With them went a paper summarizing the findings of the various Anglo-American 'productivity teams' on human relations in American industry and one prepared by Sir George Schuster on conclusions from the projects sponsored by the Human Factors Panel of the Committee on Industrial Productivity, of which he was chairman.

The Ministry of Labour has now published a report on this conference*, which includes as appendixes the papers referred to. Sir George Schuster's paper is particularly welcome since, although condensed, it gives the first comprehensive report on the work of the Human Factors Panel, with a summary of the results of the group of researches which the panel sponsored.

The conference consisted of two kinds of meeting. There were general sessions, at the first of which the proceedings were opened by an address from the Minister; at these sessions speakers introduced the main groups of questions. In addition, Sir Cuthbert Clegg, president of the British Employers' Confederation, and Mr. T. Williamson, of the General Council of the Trades Union Congress, spoke on the paper on the reports of the Anglo-American 'productivity teams', and Sir George Schuster introduced his own paper. For the second type of meeting the conference broke up into groups, each group discussing one of the four main topics. These discussions were free and informal, and at their conclusion an outline of the report from the discussion group to the conference in general session was agreed upon and later prepared by a *rapporteur* for each group. The reports, which were considered in final sessions of the congress, are now published with a summary of the discussion on them.

At a fairly early stage in the conference, Mr. Lincoln Evans, general secretary of the Iron and Steel Trades Confederation, struck at the root of the problem of human relations in industry when he said: "We shall never get that relationship, each with the other, really right unless we can get the proper climate in industry; and we shall never get that unless industrial relations are based on something broader than the conception of two sides in industry".

* Ministry of Labour and National Service. Report of the Human Relations in Industry Conference, held at the Institution of Civil Engineers, London, March 18–20, 1952. Pp. vi+128. (London: H.M.S.O., 1952.) 3s. 6d. net.

Sir Cuthbert Clegg, president of the British Employers' Confederation, referred to the same point when he spoke of the vital necessity in our present economic situation of building up a greater sense of common interest and the development of mutual confidence between employers and work people. Sir Richard Snedden, also of the British Employers' Confederation, further supported Mr. Lincoln Evans's contention that industry should not be regarded as being made up of two sides. But as the conference proceeded, despite the efforts made by speakers from the employers' associations and the trades unions to avoid the use of the language of negotiation, it became clear that a good many of those present were still thinking of industry in terms of the conflict of interest between two sides. Perhaps it was this which led one speaker in the general discussion to protest that in a conference of this size it was not possible usefully to discuss many of the fundamental problems of human relations in industry.

The scientific aspects of the questions were considered by Sir George Schuster in his speech. His particular concern was to deal with the question: "How far and on what points is more knowledge required as a guide to the right handling of human factors, and what steps should be taken to obtain such knowledge and ensure its utilization?". His general approach was governed by his belief that there is a real need for more systematic studies, but that such studies should be directed to meet known needs, and that the methods and research workers must inspire the confidence of those concerned with the practical conduct of industry, whose active interest and collaboration are essential. Although distinguishing five main groups of human problems in industry, Sir George emphasized the close relation between them and directed attention to the fact that circumstances outside the factory should not be ignored. He advocated, in fact, an ecological approach. Sir George contended that if 'scientific' were used in the wide Baconian sense, in which it included any orderly empirical study of the natural world, then the methods used for the study of human behaviour could fairly be described as scientific.

It must be admitted that the proceedings at the conference provided a good deal of evidence that the answer to Sir George Schuster's question: "Have we enough factual knowledge of what is happening in industry as a whole or are we putting forward opinions based on a narrow range of our own experience, or on intuition or preconceived ideas?", is in the negative. The reason lies to some extent, at least, in the difficulty in identifying the real problem presented by a situation. This is shown in the confident assumptions sometimes made in industry on matters of morale and motivation, and also by the bewilderment aroused by behaviour which cannot apparently be logically explained. Failure to diagnose the nature of a problem from the symptoms tends to lead, if not to its dismissal, to its explanation in terms satisfying to the observer. The formulation of problems of human relations by those in industry in a fashion which permits their attack by scientific study is not easy; if, as is commonly the case, this consequently falls to the lot of the researcher, he has to convince both management and worker that he is attacking what is really a need for knowledge.

It was also clear that there has been a failure in communications between those who undertake scientific studies of human problems and those who are in the positions to make use of the knowledge acquired. Although some responsibility must be placed on the failure of the scientific worker to record his results in a fashion easy for the industrial manager to understand, there is a suggestion that in this field, too, industry is suffering from a lack of technologists who can translate the results of basic research into effective action.

Sir George Schuster had certain practical proposals for tackling some of the problems he raised. After referring to the discussions which had been in progress between the Department of Scientific and Industrial Research and the Medical Research Council about arrangements for the conduct of research in the human factor field, he suggested that the Ministry of Labour should set up a departmental advisory committee to watch the whole field, to identify problems and to keep in touch with research and progress. He advocated also an expansion by the universities, and particularly their social science departments, of studies of human problems of industry. The universities are particularly well placed, he suggested, to establish contact with industry in their area and to provide continuity of research, which is an essential requirement in the training of the new research workers who are needed if any expansion of activity in the study of human relations in industry is to be undertaken.

SCIENTIFIC ACHIEVEMENTS OF M. V. LOMONOSOV

Russia's Lomonosov

Chemist, Courtier, Physicist, Poet. By Boris N. Menshutkin. Translated from the Russian by Jeannette Eyre Thal and Edward J. Webster under the direction of W. Chapin Huntington. (Published for the Russian Translation Project of the American Council of Learned Societies.) Pp. ix+208+5 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1952.) 25*s*. net.

FROM time to time the scientific world has had its attention directed to the achievements of Mikhail Vasilyevich Lomonosov (1711–65), one of the many distinguished men of science of whom Russia is so justly proud. Born in a village on the coast of the White Sea, he studied science and metallurgy in Germany and returned to Russia in 1741, becoming a member of the Academy of Sciences in St. Petersburg, where he worked and taught until his death. Lomonosov was a grammarian, poet, historian and man of affairs as well as a scientist, and his collected works have been published by the Soviet Government. Although not mentioned by German historians of chemistry such as Kopp and E. von Meyer, he was quoted with appreciation by Demachy and by Hoefer (who thought the chemist and the poet were different

persons). B. N. Menshutkin published an account of his work in 1904, and excerpts from his writings in Ostwald's "Klassiker" (No. 178) in 1910, and from these Lomonosov became better known outside Russia. Since then, B. N. Menshutkin has studied unpublished sources, but a comparison of the present book with an earlier study published in 1912 does not reveal much new material of importance. The book has been translated from Russian, and not very well; the names of Thomas Young and Fresnel, for example, appear as "Jong" and "Frenelle".

The main tendency of the book is the claim that Lomonosov anticipated many important discoveries, including those of Lavoisier, and that historians of science have denied him his true rights. Much of what is claimed for him (with an absence of reference to sources in many cases) is, however, not his property. A few examples may be given, and the editors have corrected more of the rather extravagant claims in the book itself. It is quite true that Lomonosov was in advance of his contemporaries in many respects, but a detailed examination of the claims made on his behalf does not substantiate some of them.

Although Lomonosov argued against the material nature of heat and regarded heat as a form of motion, this had been said long before by Francis Bacon, and the nature of the motion had been more correctly described by Bernoulli (who was in St. Petersburg) in 1738; he presented a kinetic theory of gases more correct than Lomonosov's. The latter assumed that the particles are rotating and that motion is transmitted from particle to particle by friction between their rough surfaces. Although Lomonosov, who had a good mathematical training, emphasized that chemistry should be developed on mathematical lines, this idea had been anticipated by Keill in 1708 and Freind in 1709, both of whom published a mathematical treatment of chemical changes in considerable detail, not to mention the book by Swedenborg of 1721 on the explanation of chemistry by geometry. The statement in the book that Lomonosov anticipated Lavoisier in stating the law of conservation of mass, together with the information that this law did not appear in books on chemistry until about 1860, will not bear investigation. Lomonosov had the idea that weight is not a true measure of mass and that weight could change in the same place if particles of an aggregate were separated so as to expose more surface to the action of gravity. He used this idea to explain the increase in weight of a metal on calcination in 1748, although a more correct explanation, that the increase is due to some material taken from the air, had been given by Mayow in 1674. It is true that Lomonosov says that "the air particles which always flow over the calcined body combine with it and increase its weight", but he explained the cause of the increase in weight in the way just given.

The claim that Lomonosov anticipated Lavoisier seems to be based on his criticism of Boyle's experiments on the increase in weight of tin on calcination, in which he said, in 1756, that Boyle should have weighed the sealed vessel before opening it and allowing the air to enter, and that Boyle's explanation that the increase in weight is due to the fixation of fire is invalid. But these statements had been made in 1679 by Cherubin d'Orléans. No details of Lomonosov's experiments on this subject survive, and in the few words of his conclusions from them he does not say that the increase in weight is due to the fixation of the air or part of the air, as Mayow had definitely said in 1674. Lomonosov had many good ideas, and if he had worked them out in detail he might well have made notable advances in science, but his duties as an academician and to some extent his irregular mode of life hampered his progress in scientific research. Yet others in even worse circumstances were not prevented from making discoveries.

It is clear from the book that Lomonosov, besides his theoretical ability, had also a keen interest in applied science; he set up a factory for making mosaics and in other ways was active in technology. He was undoubtedly a man of genius, but no service is done either to his memory or to the history of science by exaggerated claims that he anticipated important discoveries attributed to others. An impartial and objective study of his scientific work would be valuable and would receive sympathetic consideration; but it is to be feared that the exaggerated and, in many cases, unfounded claims made for him in the present book will create an unfavourable impression among those who have some knowledge of the facts of the history of science, and in this way will defeat the praiseworthy object of the author in making known the services of one of Russia's great men.

J. R. PARTINGTON

THE ANATOMY OF CHROMOSOMES

Allgemeine Pflanzenkaryologie

Von Prof. Dr. Georg Tischler. Hälfte 2: Kernteilung und Kernverschmelzung. (Handbuch der Pflanzenanatomie, Allgemeiner Teil: Cytologie (Die Organe der Zelle), Band 2.) Zweite Auflage. Lieferung 1. Pp. 384. 58 D. marks. Lieferung 2. Pp. 385–720. 48 D. marks. (Berlin-Nikolasee: Naturwissenschaftlicher Verlag vorm. Gebrüder Borntraeger, 1951.)

IN 1922 Prof. G. Tischler, of the University of Kiel, published an account of the nucleus and the chromosomes in plants. This work was a section of the cytological part of an encyclopædic work on plant anatomy. The present two volumes are a new edition expanded to twice the original size and now illustrated with 466 text figures.

Prof. Tischler's first edition was fully in keeping with the standards of chromosome studies in plants at the time, standards which did not widely depart from those of plant anatomy. That is to say, it was descriptive and it gave weight to each author according to the mass of his publications. The new edition follows the same method. It never resists the temptation to be complete, and it is, in fact, most exhaustive. No controversy is so dead that it cannot here be revived and exhibited; no figure so doubtful or so hazy that it cannot here be accurately reproduced. Description, forgotten history and experimental data are set forth in what is no doubt a carefully considered order. But it is the order of plant anatomy translated to another level. Torn into the shreds of botanical subdivision, we find the dismembered unity of chromosome behaviour. The immediate interpretation we see described with utter impartiality as between the worst and the best. How wise the author is, in these circumstances, to leave the genetical and physiological interpretation out of the picture altogether.

Can such a book have any value? It is difficult to say. For, although there are perhaps twenty thousand references to names, with and without

dates, in solid masses in the text, in the countless footnotes, and in the legends of figures, there is no list of references, no index and no contents. These will follow: but without them one can scarcely use the volume even as a work of reference.

Prof. Tischler's work will stand as a monument to his devotion, his industry, and his learning, the greatest which have ever come to fruition in this field of knowledge. Moreover, with the passage of time it will not diminish in value. A hundred years hence it will still show in the utmost detail how an attitude towards scientific research and a programme of scientific publication conceived in the nineteenth century could be faithfully continued in the middle of the twentieth century, thereby fulfilling the hopes of a generation which had passed away.

C. D. Darlington

ANGLO-SAXON MAGIC AND MEDICINE

Anglo-Saxon Magic and Medicine

Illustrated specially from the Semi-Pagan Text "Lacnunga". By J. H. G. Grattan and Charles Singer. (Publications of the Wellcome Historical Medical Museum, New Series, No. 3.) Pp. xii+234+7 plates. (London: Oxford University Press, 1952.) 28*s*. net.

THIS welcome and noteworthy addition to the scanty literature of Anglo-Saxon medical history is the combined work of two authorities, each eminent in his own sphere. The three-volume treatise by T. O. Cockayne, dated 1864–66, entitled "Leechdoms, Wortcunning, and Starcraft of Early England", was an important contribution, as also were J. F. Payne's Fitzpatrick Lectures of 1903, which were printed in the following year under the title "English Medicine in the Anglo-Saxon Times".

The late Prof. J. H. G. Grattan, an unrivalled expert in Early English language and literature, has collaborated with the leading medical historian of the present day, Prof. Charles Singer, in this book which, although smaller, is a worthy successor to Cockayne's and Payne's works. The first part, roughly one-half, of the book consists of a general survey of magico-medical practice in Anglo-Saxon England, by Prof. Singer, while the remaining part is the text, with translation on the opposite page, besides notes and a glossary, of "a magico-medical commonplace book" known as "Lacnunga", from the sole surviving manuscript in the British Museum, where it is listed as MS Harley 585. It seems to have been written, about the year A.D. 1000, by a 'leech' who was not of the priestly class, and who, as Prof. Singer remarks, "still dwells in the barbarian world of magic and hardly emerges therefrom". He begins with remedies for the head and eyes, and works his way downward in the time-honoured fashion. More than a hundred medicaments are mentioned, of vegetable origin for the most part, and not all of them can be identified. Among the animal remedies are fox's grease, hind's milk and crab's gall. Apparently more important than the remedies themselves are the incantations and exorcisms which must accompany their administration. One of these is the "Lorica" of Gildas, written in Ireland in the seventh century; there is also a spell against flying venom and a lay against elfshot, besides a Christian prayer for sore eyes.

The lays were to be sung over the medicines three times, and also "into the man's mouth and both ears". Nor is veterinary medicine neglected, as exemplified by a "rite for lost cattle" and a "charm for a sprained horse". Anglo-Saxon medicine appears to have little rational basis. According to Singer, it cannot be regarded "as an early stage of what is to become a great intellectual movement". It is, rather, "a final pathological disintegration of the great system of Greek medical thought". As examples of the charms may be mentioned the formula against malaria: "Flee, ye fevers, eighty-thousand angels are after you", and, for what are called seizures, the patient is advised to "take a hazel stick. Cut thy name thereon: fill the name with blood, and throw it over the left shoulder into running water, all silently".

While all those recipes are of interest to the medical historian as evidence of a decadent epoch in the progress of the healing art, the "Lacnunga" will probably be of greater value to the student of Anglo-Saxon than to the medical man. The medium by which the information is conveyed is at least as interesting as the facts themselves. The brief survey of the grammar contained in the last fifteen pages of the book may be of much value to students of linguistics, while the section dealing with "Semantics of Anglo-Saxon Plant-Names", giving the Anglo-Saxon, English, and Latin or Linnæan versions, forms a useful contribution to botany. The well-chosen illustrations are in themselves most informative, although it is perhaps unfortunate that the plates are not described in more detail. As is to be expected, the book is clearly printed and well produced.

Douglas Guthrie

TEXT-BOOK ON RELATIVITY

The Theory of Relativity

By Prof. C. Møller. (International Series of Monographs on Physics.) Pp. xii+386. (Oxford: Clarendon Press; London: Oxford University Press, 1952.) 35*s*. net.

THIS book is based on lectures given during the past twenty years by Prof. C. Møller, who is professor of mathematical physics in the University of Copenhagen. The preface describes it as a text-book for students in physics whose mathematical and physical training does not go beyond the methods of non-relativistic mechanics and electrodynamics. In arrangement the book follows a conventional pattern, slightly more than half being devoted to the special theory of relativity (including an introductory chapter with a historical survey) and the rest to the general theory, including a little on cosmological models (Einstein and de Sitter). It ends with some mathematical appendixes, an author index and a subject index which, like most subject indexes, might with advantage be fuller.

The style is clear and persuasive, and the author shows himself a skilful teacher in the way in which he dilutes the abstract with the particular. The mathematical machinery of tensor calculus is developed as the need arises, first for the special theory and then for the general theory. By the time the reader reaches the end of the book, he should have a good basic knowledge of the theory of relativity.

Ever since Minkowski published his famous paper on space and time in 1909 there have been two ways of looking at relativity—the old kinematical way, with constant reference to measuring-rods and clocks, and the Minkowskian way, in which the geometry of the four-dimensional continuum dominates. Prof. Møller definitely favours the former. He writes: "On the whole, the epistemological significance of the four-dimensional representation should not be exaggerated" and ". . . it must be emphasized that such a representation is quite formal". But of course he cannot get on without the space–time continuum, which is introduced in Chapter 4 with these cautionary remarks. There are even space–time diagrams on pp. 96, 152, 168; but they are queer diagrams—topologically incorrect representations of space–time, since the axes of (x_1', x_4') should be both inside (or both outside) the axes of (x_1, x_4) (cf. Fig. 1 in Minkowski's paper in "The Principle of Relativity", p. 78 (London: Methuen, 1923)).

It seems to me that the book would have been better if Prof. Møller had been more sympathetic to the Minkowskian way of looking at things. When the head begins to swim with contracted rods and slowed clocks, the best antidote to confusion is a simple space–time diagram. Thus, in Chapter 8, which leads to the general theory of relativity through the "principle of equivalence", it would be good to recognize that the ends of a short rigid measuring-rod are simply adjacent world-lines with a constant normal separation between them. But having recognized this, and remembering how Herglotz's masterly treatment of rigid-body motions (*Ann. d. Physik*, 31, 393; 1910) restricts such motions, one cannot but be surprised at the simple dogmatism of Prof. Møller's treatment of that thorny problem—the rotating disk. If a second edition of the book gives him an opportunity to revise Chapter 8, I hope he will use it to give the reader a clearer idea of the concept of rigidity in relativity.

J. L. Synge

EXPERIMENTAL EMBRYOLOGY OF BIRDS

The Epigenetics of Birds

By Prof. C. H. Waddington. (Cambridge Biological Studies.) Pp. xvi+272. (Cambridge: At the University Press, 1952.) 35*s*. net.

PROF. C. H. WADDINGTON'S choice of the title of his new book is eye-catching and stimulating if for no other reason than that the word 'epigenetics' connotes in the minds of many embryologists a variable and changing spectrum of meanings. The author's rather broad use of this word as a name for "The science concerned with the causal analysis of development" may be somewhat surprising and unfamiliar to most embryologists, particularly, because such usage would seem to leave little room for ideas about the alternative, 'preformistic' causal aspects of development. Nevertheless, as one reads through the book it becomes apparent that 'epigenetic' is being used in a sense sufficiently broad to include both the interactive (inductive) and segregative (localizational) mechanisms of the developmental system. However, since Prof. Waddington's major concern is not the presentation of a general thesis of avian development (although his title might suggest it), we have little concern with the inevitable semantic difficulties which result from the use of the word 'epigenetics'.

The central purpose of the book, as the author states in the preface, has been to review the literature of experimental embryology of birds from 1930 up to about 1950. The book is fortunately much more than a simple review, for the author has frequently interjected his own evaluation and interpretations along with his description of the results and interpretations of the various workers in the field. Moreover, he has done this in a commendably objective and undogmatic way. His warnings about the making of interpretations of data accumulated by experimental methods and procedures that do not specifically warrant them should be accepted as a healthful shaking-up in our thinking about the mechanisms of bird development, regardless of whether all of us agree with his interpretations in particular instances (for example, interpretation of the organization of the unincubated *chick* blastoderm as a "single entity" on the basis of the results of studies of the unincubated *duck* blastoderm). One of the major contributions of the book is the comparison and critical evaluation of the many and sometimes conflicting results of the German, French, English and American workers—an analysis which has not been made previously in anything like as thorough a fashion.

The plan and order of presentation of the subject-matter follow in the main those of developmental chronology, beginning with an introductory chapter on technical methods and proceeding through a discussion of our knowledge of endoderm, primitive streak and embryo formation on to problems of organ system formation in later stages. The main emphasis has been devoted to such general problems as germ-layer interaction and primitive streak organizer (induction) activities. Special chapters deal briefly with a comparison of bird development with that of other vertebrates, biochemical mechanisms, feather development and pigmentation and with certain genetic effects and their phenocopies.

In the final and one of the most thought-provoking chapters in the book, the author has summarized the status of our knowledge of the "development of the epigenetic organization of the chick". This amounts in large part to a presentation and evaluation of our information about the regulative capacities of the early embryo. Among a number of valuable suggestions for future lines of attack is a most interesting one concerning the physiological mechanisms which underlie the processes of localization (or "segregation"). It is true that most of our information concerns the inductive (cell or tissue interactive) mode of differentiation—perhaps because this is most easily demonstrated experimentally—whereas almost nothing is known about the localizational or "segregative" mechanisms. Prof. Waddington suggests that "they offer to the embryologists of the future a problem perhaps even more important than that of the mechanisms of induction". It is obvious to all, however, that we still know very little about the actual mode of cell–cell interaction; for example, whether this is mediated by cell–cell contact and/or by diffusible substances remains an important problem in developmental physiology.

Embryologists will find this little book quite readable and provocative. It is well illustrated and contains a rather extensive bibliography. Prof. Waddington is to be congratulated for his efforts, which have produced a book both timely and valuable.

Nelson T. Spratt, jun.

Colloidal Dispersions

By Earl K. Fischer. Pp. vii+387. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950.) 60s. net.

THE dust-cover of this book says that "Dr. Fischer's book is the first to cover both the theoretical and practical aspects of colloidal dispersions". This extraordinary statement becomes comprehensible when it is seen that the book is not, in fact, about colloidal dispersions at all, but deals with coarser systems. It deals, in fact, with the same field as J. M. Dellavalle's "Micromeritics" (New York: Pitman Publishing Corporation, 1943), although there are considerable differences of emphasis and allocation of space to topics. A name for these very finely divided systems would be valuable, except that further divisions would continually arise: we might go from micromeritics to microteromeritics and microtatomeritics! From the point of view of free surface energy, the particle size is rigorous for spherical particles: for fine dispersions, all properties are highly dependent upon shape. 'Fine powders' or 'fine dispersions' would seem to be entirely adequate, without straining after an exactitude which does not and cannot exist.

"Colloidal Dispersions" is of little interest to academic workers but should be valuable to applied chemists. After an orthodox introduction of four chapters, rheological properties are discussed fully in seventy-seven pages, followed by thirty-four on surface-active agents in which pp. 225–227 contain an astonishing crop of peculiar statements. The remainder of the book describes grinding. The work is well documented by references to a wide variety of work and systems and forms an interesting chemical companion volume to Delavalle's more physical and fundamental book.

A. S. C. Lawrence

Bird Migrants

Some Aspects and Observations. By Eric Simms. Pp. 212+16 plates. (London: Cleaver-Hume Press, Ltd., 1952.) 15s. net.

THE author declares that the purpose of his book is to introduce more people to the fascination of bird-watching and worth-while observations. It is now sixteen years since Landsborough Thomson's "Bird Migration" was published and became the standard work, so that there is room for a fresh account in view of the considerable advance in the study of bird navigation and orientation.

Perhaps the best chapters in this book cover a discussion on the latest theories, including the work by Griffin, Kramer and Matthews, and an exposition of seen and unseen migration. The author's experience as an airman enabled him to confirm that migration is usually at a level below the contours of the higher hills, and rarely indeed above three thousand feet. He describes the well-known cross-country migration, chiefly autumnal, between the Wash and the Severn, which he observed along the northern escarpments of the Cotswolds. East-coast migrants pour into the Wash southwards from Lincolnshire and westwards along the Norfolk coast, and are canalized along the Fen rivers south-westwards and follow the Avon to the Severn Estuary.

This is a promising first book. Unfortunately, it shows signs of hasty construction: the map of bird observatories omits the Lundy and Saltee stations, and there are too many vague generalizations with no supporting evidence. Thus: "migration and dispersal may happen not only amongst birds of different species, but amongst individuals of different age in the same species"; "The spotted flycatcher . . . in the mainland is not really uncommon except in some of the more remote groups of islands"; "At sea auks battle in the breakers to reach low-swimming herring and get tossed exhausted on the beach"; "the lonely and treeless Fair Isle, originally discovered by Dr. Eagle Clarke"; and the error made by Coward is repeated in stating that gannet and shearwater migrate overland in autumn, for "records cannot be invariably associated with weather". W. E. Kenrick, on the contrary, found by careful research into the meteorological records that the days preceding each inland recovery of these essentially marine birds were stormy, as a rule with some notable gale from a westerly quarter. These inland records proved to be of dead, dying or exhausted birds overtaken by weather and driven inland.

R. M. Lockley

An Introduction to Acoustics

By Prof. Robert H. Randall. (Principles of Physics Series.) Pp. xii+340. (Cambridge, Mass.: Addison-Wesley Press, Inc., 1951.) 6 dollars.

THIS useful book, of intermediate degree standard, has been written mainly for students of physics, but it deserves to have a much wider range of readers, to include engineering students and others who may wish to specialize in communications and electro-acoustics. Indeed, a good knowledge of the basic principles of acoustics is absolutely essential to all who are engaged in the many practical applications of the subject.

The treatment given in the book follows a logical course, beginning with a study of vibrations as a preliminary introduction to the wave equations, and the importance of these topics to all branches of physics and engineering is stressed.

The mathematics used in the text should, in the main, be well within the compass of the students for whom the book is intended, except perhaps the complex notation used in Chapter 5, but even here the author gives only the essential material sufficient for the understanding of the text. The value of electrical analogies is fully recognized, and good use is made of such analogies in the solution of acoustical problems.

While giving a thorough account of the fundamentals of the subject, the author has not neglected the more popular and applied features, and has devoted considerable space to such topics as speech and hearing, loud-speakers, electronic devices, etc. In general, the book is quite a valuable contribution to the literature on acoustics.

The Basuto

By Hugh Ashton. (Published for the International African Institute.) Pp. xi+355+17 plates. (London, New York and Toronto: Oxford University Press, 1952.) 35s. net.

THIS book gives a general, but accurate and comprehensive, account of the people of the wealthiest, and the largest in population, of the South African High Commission Territories. Basutoland came into being during the nineteenth century through the political genius of its chief, Moshesh; and through good fortune, and the warlike qualities of its people, managed to survive Zulu and Afrikaner attacks to emerge into the twentieth century as the largest native African State or tribe in southern

Africa. It takes its name from the Sotho or Suto, a group of southern Bantu people that extends from the Bechuanaland Protectorate southward to Basutoland. Thanks to the research of Prof. Schapera, anthropological attention has been mainly focused on the northern or Bechuana section; the publication of H. Ashton's book on the southern, and numerically far larger, section will help to redress the balance and, in addition, provide valuable comparative material and lead to a much fuller understanding of this southern Bantu people.

Some sections of the book, in particular the chapter on medicine, magic and sorcery, and the appendix on kinship marriage, will be of particular interest to social anthropologists; the greater part of it, however, is more general in character and will appeal to a far wider public. It is written by a man who is a competent administrator as well as an anthropologist, and who is thus able to give a direct and straightforward account of an African people in the twentieth century and to avoid the obscurity and abstraction which characterize the language and content of so many current anthropological monographs. In Chapter 15 on law, for example, Ashton describes the kind of law administered in the courts of Basuto ward chiefs immediately prior to the changes introduced by the British Government after the Second World War, quoting extensively from the court records of Chiefs Mosue and Bereng and giving us a study of what was actually happening in these particular courts. Such a chapter is much less likely to be coloured by the preconceptions of the field observer and his particular informants.

"The Basuto" is a book that has been worth waiting for and which should appeal to a wide range of readers. Its only regrettable feature is its price; it is a pity that the publicity section of the Commonwealth Relations or High Commissioner's Offices could not have subsidized its publication.

G. I. Jones

Papers on the Basic Principles of Statistical Physics

By N. S. Krylov. Pp. 204. (Moscow: Academy of Science of the U.S.S.R., 1950.) 18 roubles.

PROBLEMS and arguments associated with the 'ergodic theorem' (or principle of continuity of path) have, from the times of Maxwell and Boltzmann to the present day, played an important part in establishing the kinetic theory. Decisive progress in the mathematics of these problems was made approximately twenty years ago, but scanty use has, so far, been made of this work for interpreting physical facts.

This book under review, which is written in Russian, was planned as a comprehensive treatise in which the recent mathematical results were applied to the statistical theories of physics. Owing to the premature death of the author, only some preparatory papers and single sections have been completed; but even the incomplete work is worth studying on account of the author's great knowledge of the mathematical aspects of every problem and its bearing on physics. The author's approach is to a remarkable extent independent of the traditional presentations of the subject; an example of his attitude may be found in the only paper he published in English (*Nature*, **153**, 709; 1944).

Time series of observations of mechanical systems as compared with time series of random observations; specification of mechanical processes in terms of Markov chains; the calculation of relaxation times; the quantum mechanics of measurement with less than the greatest admissible accuracy: these and similar topics, which are relevant to the foundations of statistical thermodynamics and the stochastic theory of irreversible processes, are surveyed and utilized in original contributions. The author's work should—if translated—appeal to an appreciable number of English-speaking readers.

R. Eisenschitz

Wild Flowers, Grasses, Ferns, Fungi, Trees

(Nature Field Series, 1.) Pp. vii+83.

Birds and Wild Animals, including Marine Mammals

(Nature Field Series, 2.) Pp. vii+83.

Insects and Spiders

(Nature Field Series, 3.) Pp. vii+72.

Shore Life, Fish, Clouds and Weather

(Nature Field Series, 4.) Pp. vii+71.

By H. Trevor Jones. (London and New York: Frederick Warne and Co., Ltd., 1952.) 6*s.* 6*d.* net each.

THE succession of new books of natural history is almost as regular as the seasons of Nature herself. Some are primarily evocative and seek to attract the reader by appealing to the imagination and the emotions. Others are purely descriptive and attempt to win the intellectual interest of the reader. In this new series of Nature books for younger readers, H. Trevor Jones has set out both to stimulate enthusiasm and satisfy curiosity, and because of the attractive way in which the text and colour- and line-drawings are combined, can reasonably claim to have succeeded. The first book describes 145 species of wild flowers, six ferns, sixteen fungi and fifty-two trees. In the second book are descriptions of 163 species of birds and seventy-six species of other animals, including a few invertebrates. In the third, 152 species of insects and spiders are illustrated, while, in the fourth, Jones includes most of the common examples of fish and other forms of fresh-water and marine life in and around Britain; at the end of this book there is a useful section on clouds and weather, with additional information on tides and currents, stars and planets. In nearly every case the illustrations are conveniently set alongside the species to which they refer.

T. H. H.

A Flower Book for the Pocket

By Prof. Macgregor Skene. Second edition. Pp. 378. (London, New York and Toronto: Oxford University Press, 1952.) 12*s.* 6*d.* net.

THIS little manual, a revised edition of a popular handbook, will provide a pleasant and instructive introduction to the study of British wild flowers. A simple system of classification is adopted in which eight groups are recognized; artificial keys are given to these groups and the natural families which comprise them. Further keys are provided to the genera in each family, and with the adequate and non-technical description of each species the beginner should have little difficulty in naming common wild flowers. More than five hundred plants are illustrated in colour, but the detail tends to be rather obscure. The author is to be commended for using, to a large extent, the nomenclature of the most recent British Flora.

RAW MATERIALS OF LIFE*

By Dr. D. P. RILEY and Dr. U. W. ARNDT
Royal Institution

AN egg contains within itself all that is necessary to make a live chick. Some air goes in through the shell and some carbon dioxide comes out; water vapour passes in and out; but apart from that, nothing is added or taken away. All the raw materials needed are already there and, given time and warmth, they are transformed into an organism capable of independent existence. These raw materials of life cannot but repay study, and, in fact, rapid progress has been made in the past few years in reaching an understanding of their complicated chemical structure.

One of the reasons why it is difficult to measure with certainty and precision the weight, size and shape of protein molecules is because many of them associate or dissociate to varying degrees in solution. A knowledge of molecular interaction in protein solutions would be of great importance to our understanding of processes occurring in the living cell and we are as yet only at the beginning of such knowledge. We have recently come to know, rather surprisingly, somewhat more about the intricate internal structure of protein molecules than we know about their grosser properties of shape and size. It is not too much to hope that a synthesis will soon be effected between the detailed chemistry of these molecules and their physico-chemical characteristics.

X-ray Analysis

X-ray diffraction analysis has been used for many years in the study of proteins. It is not our present purpose to survey all that has been done in this field so much as to assess the relative value of various possible procedures in relation to the type of information it is desired to obtain.

The molecular weight of a 'globular' protein can be determined with considerable accuracy from a knowledge of the volume of the crystal unit-cell, its density and content of water or electrolyte solution. As is well known, the value derived in this way may be a multiple of the true molecular weight, but, apart from this factor, the degree of attainable precision is very great. The method is limited to those proteins which form large and sufficiently perfect single crystals. This elementary single-crystal procedure has been disappointing as a means of obtaining rapidly and unequivocally the actual molecular dimensions, although it is, in principle, capable of giving them with great precision. An alternative, and more generally applicable, method of studying molecular size and shape is afforded by the scattering of X-rays at low angles by solutions of proteins. In sufficiently dilute solutions, if no aggregation occurs, the observed scattering is a simple multiple of the scattering by a single molecule, averaged over all orientations. The derived quantity is a length, the 'radius of gyration', related to the moment of inertia, and does not uniquely define a volume or shape. However, by working under absolute conditions or by careful comparison with a standard protein of known molecular weight, the low-angle method provides molecular weights (or volumes) directly. Again, by the examination of concentrated solutions it is sometimes possible to estimate one or more molecular dimensions, if various simple assumptions are made. The combination of the three approaches should allow a fairly confident and rapid assessment of the shape and size of the molecule in favourable cases.

The forces acting between neighbouring protein molecules in concentrated solutions can, in principle, be measured by a process of Fourier inversion of the scattered X-ray intensity at low angles. The effect of changes in *p*H and ionic strength can be studied.

Many analogies exist between light-scattering methods and low-angle X-ray techniques, and the two procedures are, to some extent, complementary.

The most that one can hope to derive directly, concerning the molecular structure of proteins, from a diffraction experiment is the scattering function for a single molecule. This function, which is always real and positive or zero, is the conjugate complex of the 'Fourier transform' or 'diffraction picture' of the distribution of scattering matter within the molecule. The most direct way of observing the molecular scattering function would be to examine a partly-ordered assembly in which all molecules possessed exactly the same orientation, but random and relatively large intermolecular distances. This is achieved in part in some fibres and it may prove possible, although difficult, to produce suitable specimens artificially. The disadvantage of working with true crystals is that the regular arrangement gives rise to intermolecular interferences which obscure the pattern due to a single isolated molecule. Much ingenuity has been used in partially overcoming this difficulty, notably by the Cavendish Laboratory school, as described by Sir Lawrence Bragg in his Guthrie Lecture (*Proc. Phys. Soc.*, B, 65, 833; 1952). But it still remains the case that details of the intramolecular chemistry have yet to be deduced with certainty from work on single crystals.

Molecular Models

If the strictly deductive procedure be abandoned, and the intellectually less satisfying (to the experimenter) procedure be adopted of working from hypothetical structural schemes, the problem becomes one of devising experimental approaches which can put such hypotheses to the test. A convenient method is to measure accurately the angular variation of intensity of monochromatic X-radiation scattered by an amorphous sample, with subsequent comparison with the intensity curve calculated from a given structural model. Alternatively, curves depicting the radial distribution of scattering matter may be the basis of comparison.

By the use of a proportional-counter spectrometer, intensity curves of this type can now be quickly obtained with an accuracy of about $\pm$ 2 per cent, and a survey of a number of proteins has been made*. All proteins, whether fibrous or corpuscular, seem to fall into three main structural types. For terminological convenience, these types will be called α, β and γ. α-Proteins include the keratin–myosin–

* Based on a Friday Evening Discourse entitled "The Chemistry of an Egg" delivered by Dr. D. P. Riley at the Royal Institution on November 7.

* The researches on protein structure in progress in the Davy Faraday Laboratory are being carried out with the assistance of Mr. W. A. Coates; publications describing the methods and results in detail are in course of preparation. Work has been greatly helped by grants from the British Empire Cancer Campaign.

epidermin–fibrinogen proteins of Astbury, also all the corpuscular proteins so far examined; silk fibroin is an example of the rarer β-proteins; and the γ-proteins constitute the collagen and gelatin group. Astbury's tripartite classification is thus of general applicability. It has further been shown that the only structural hypothesis so far studied which agrees with the scattering curves for α-proteins is Pauling, Corey and Branson's α-helix with about 3·7 amino-acid residues per turn in one coiled polypeptide chain. Here, the agreement is very close and the structure may be considered to be established beyond reasonable doubt. β-Proteins probably have fully extended polypeptide chains, while the configuration in the γ-proteins is not yet known.

A protein molecule consists of one or more main polypeptide chains:

$$(-NH-CHR-CO-)_n \text{ or } \left[\begin{array}{c} \\ CO \\ | \\ -NH-C_\alpha-H \\ | \\ C_\beta \end{array}\right]_n$$

to which are attached the side-groups, *R*, of relatively simple, and known, structure. The C_α carbon atoms at which these attachments occur are, in general, asymmetric and give rise to optical activity. The absolute configuration around the C_α atoms is now known and is described as *lævo* or L-. The above formula depicts it according to the usual convention: C_α is in the plane of the paper, the bonds to CO and C_β are below, and those to NH and H above, this plane. The configuration being identical for all C_α atoms in proteins, there are only two ways of building an α-helix: a left-handed helix with the *R* groups attached in one specific way, or a right-handed helix with the *R*-groups fixed in the alternative way. For brevity, these two structural types may be called α_1 and α_2, and their full descriptions are:

$$\alpha_1 = LH\ C\beta 2\ \text{L-}C_\alpha;\ \alpha_2 = RH\ C\beta 1\ \text{L-}C_\alpha,$$

where $C\beta 1$ and $C\beta 2$ refer to the two alternative positions of the first carbon atoms ($C\beta$) of the side-chains. The equivalent enantiomorphs, α_1' and α_2', can exist in synthetic polypeptides but not in natural proteins:

$$\alpha_1' = RH\ C\beta 2\ \text{D-}C_\alpha;\ \alpha_2' = LH\ C\beta 1\ \text{D-}C_\alpha.$$

The α-type of protein structure can thus be divided, in principle, into two sub-types, α_1 and α_2, and there is no *a priori* reason why they should not both exist in Nature or even co-exist in one and the same protein molecule. By calculation, it can be shown that the amorphous scattering curves from α_1 and α_2 present recognizable differences, and the possibility therefore exists of distinguishing between them by experiment. Work along these lines is at an early stage, but it can provisionally be said that, while α_1 seems to be the favoured structure in serum albumin, a mixture of α_1 and α_2 may exist in insulin. It is tempting to identify these with the *A* and *B* fractions of Sanger, and, indeed, the presence of a proline amino-acid residue (as in *B*) can be shown to impose the α_2-configuration on the polypeptide chain in which it occurs. Examination of the separated fractions should settle the point.

Two methods are open to us for the examination of the side-chains by these X-ray scattering methods. One is to place the amino-acid residues along the main chain in the order found by Sanger by chemical means, and to calculate their effect on the intensity curve; the other is to perform a 'difference-Fourier' inversion of observed-minus-calculated intensity functions. The latter procedure gives a radial distribution curve corresponding to those parts of the structure which had been omitted from the first calculations, that is, principally, the side-chains. It has been shown in these ways that the effect of the side-chains on the scattering is not sufficiently specific to mask the dominating features imposed by the basic folding of the polypeptide chain.

In the case of insulin, the molecular structure would be almost completely determined if it were known how the *A* and *B* fractions are linked by cystine, —S—S—, bonds. The 'Courtauld' space-filling atomic models designed by G. S. Hartley and Conmar Robinson are of great help here; but a final unique solution still escapes us. One feature, however, which emerges from this sort of study is that neighbouring helices may well be skew to each other. If this is generally true, it would greatly complicate the detailed interpretation of Patterson series derived from single-crystal data.

Whether or not a given protein molecule has a unique structure is a matter for some doubt. Several workers have directed attention to the similarities between proteins and the silicate minerals. The possibility in proteins of 'isomorphous' replacement of 'non-specific' side-chains cannot be excluded and may even be probable. Such possibilities only lend weight to the argument that a detailed solution of the structure of a protein molecule is a matter for an integrated chemical and physical approach. On one hand, controlled degradation of the molecule with separation of the breakdown products, and, on the other, the use of an electronic computing machine in connexion with highly accurate intensity curves, would, in rational combination, lead to considerable advances in our understanding of the 'raw materials of life'.

Survey of Structural Types

We should like to appeal for help from other centres in providing specimens for a survey of structural types in polypeptide molecules which we wish to undertake by the X-ray scattering method. It is not necessary in this sort of examination for the material to be crystalline; but adequate purity is important, particularly as regards freedom from inorganic salts. Purification could, of course, be done by us where necessary. Salt-free freeze-dried material is very suitable, as is any fine powder or amorphous mass. Fibrous material is less convenient. At present, the technique requires the use of about 100 mgm. of material to obtain the best results, but smaller quantities could be examined if need be.

We should be most grateful to any colleagues who might feel that they would like to contribute specimens to this survey. Perhaps they would, in the first place, write to us (at the Royal Institution, 21 Albemarle Street, London, W.1), giving details so that unnecessary trouble on their part could be avoided. If desired, the samples could be returned after examination, which should not normally affect them. It is desired to include in the survey natural proteins of all kinds (common and uncommon), denatured proteins or proteins which have been submitted to various chemical or physical treatments, synthetic polypeptides and natural polypeptides.

PHYSICS OF THE HIGH ATMOSPHERE

A SESSION on the physics of the high atmosphere, under the chairmanship of Prof. A. M. Tyndall, was held on September 5 at Belfast by Section A (Physics and Mathematics) of the British Association. The meeting brought together four speakers who discussed this topic from different points of view, using what might be called the passive, the active and the direct observational, and the theoretical approach.

Historically, the scientific study of the earth's upper atmosphere evolved from ground observation of phenomena such as the auroræ and trails of meteors. It is remarkable, as became apparent from the paper by Dr. F. E. Roach (Naval Ordnance Test Station, Inyokern, Calif.), that this passive observational approach, when performed with modern, highly sensitive instruments, can still yield most valuable information about the properties of the upper atmosphere. An example of this type of approach has been the researches by Dr. Roach and his colleagues on the faint light emission from the night sky, known as the night air glow. They have been concerned mainly with the oxygen lines 5577 A. and 6300 A. which already formed the basis of Lord Rayleigh's classical work. It is interesting to note that the modern mean value for the intensity of $2{\cdot}8 \times 10^3$ quanta/sq. cm. column/sec. agrees rather closely with the value of $1{\cdot}8 \times 10^3$ obtained by Lord Rayleigh with his primitive equipment. Roach's measurements, conducted with photoelectric equipment under unusually good atmospheric conditions in the California desert, have led to the conclusion that the night air glow shows a maximum which occurs, on the average, near local midnight. On the basis of a detailed study of one night, Roach and Pettit[1] proposed that the isophot pattern of λ 5577 of the night air glow remains stationary with respect to the sun, while the earth rotates underneath.

Dr. Roach and his colleagues have tried to test this idea further by comparing the records of two stations—Cactus Peak, Calif., and Haute Provence, France—which are eight hours apart in terms of longitude. They have found that there appears to be some resemblance of the isophot patterns and sometimes of the maxima; but on the whole, the isophot patterns do not remain well preserved, indicating the influence of variable factors. When they attempt to measure the height of the emitting layer by means of triangulation methods, they find its altitude to be about 180 km. By other techniques, they have found altitudes in the neighbourhood of 250 km. All these values are in definite disagreement with photochemical theories which, in considering a purely static atmosphere, place the altitude of the emitting layer at approximately half that observed.

Another experimental approach of great interest was intended to establish the correlation between the intensities of the emission lines λ 5577 and λ 6300, a correlation which is to be anticipated since λ 5577 is a transition from the ^1S-state of O I (which has a lifetime $\sim \frac{1}{2}$ sec.) to the ^1D-state, and since λ 6300 is a transition from the ^1D-state (which has a lifetime of $\sim$ 100 sec.) to the ^3P-state of O I. The comparison between the intensities of these two lines is most interesting: although generally about the same at the beginning of the evening, they show no relationship and even inverse correlations during the night. The correlation between λ 6300 and the total number of electrons in the F-layer, however, is very good. This again may be taken as an indication of the variability and instability of the very high atmosphere which becomes apparent because of the long lifetime of the ^1D-state.

A more active approach to the study of the atmosphere has been reserved to this century. The probing of the upper layers by man-made radio signals commenced with the now famous experiments of Appleton and of Breit and Tuve. The values of the critical radio frequencies give immediately the concentration of electrons as a function of altitude. Mr. W. R. Piggott (Radio Research Station, Slough) discussed the vast amount of information which can be extracted from ionospheric reflexion data provided one looks at them in very special ways. Of particular interest is the influence on the upper atmosphere of tidal forces and their identification from the variations of electron density. There exists, for example, a definite twelve-hourly oscillation of the F-layer with a maximum height at local noon and midnight.

Expressing the variation of electron densities N by the equation

$$\frac{dN}{dt} = q - f(N,X),$$

one can look separately at the agents which produce electrons (q), and other effects (X) which lead to the disappearance of electrons. It is found that this expression holds quite well in the lower ionosphere where the mean free paths are small and the layers are essentially in static equilibrium with respect to winds and oscillations. At the greater heights, however, the lifetime of the electrons increases as the collision frequency decreases, so that the atmosphere is no longer stable to large density changes.

These influences, which cause variations in the electron density, can be looked at in different ways. Mr. Piggott discussed, as an example, the dependence of q on the sun. It is observed that the absorption in the E-region shows a maximum at noon and that during an eclipse the electron density in the E-region decreases very sharply. The upper layer, however, exhibits a completely different behaviour: for example, the formation of a new F-layer has been observed during a recent eclipse.

One of the most valuable features of ionospheric research is the possibility of geographical studies from data which come from fifty to sixty international stations distributed over the face of the earth. Such studies have shown the important influence of the earth's magnetic field on phenomena in the upper atmosphere: for example, the electron densities in the F_2-layer show a sharp dip ('cusp') in the immediate vicinity of the equator where the magnetic field is horizontal.

The high-altitude sounding rocket, the newest experimental technique for studying the upper atmosphere, was described by Dr. S. F. Singer (Office of Naval Research, United States Embassy, London). Rockets make possible measurements *in situ* by bringing instruments into direct contact with the upper regions of the atmosphere. They are unique, since they allow measurements of extra-terrestrial radiation, electromagnetic as well as corpuscular (for example, cosmic rays), before these radiations are modified or absorbed by the air. Of particular importance for the theory of upper atmosphere phenomena are measurements of the solar ultraviolet emission.

The results of rocket experiments of the past five or six years have, in many cases, confirmed conclusions already arrived at from sea-level observations. In many other cases they have provided more accurate and reliable data than can be obtained from the extrapolation of low-altitude measurements—for example, in determining the altitude distribution of ozone; and in a few cases they have given information which is completely new and sometimes unexpected—for example, the existence of gravitational separation of atmospheric constituents near the 70-km. level and the existence of a high-intensity electric-current stream above the magnetic equator.

Perhaps the greatest disadvantages of the rocket as a vehicle for high-altitude experiments are the high velocities and the short times spent in the upper atmosphere ($\sim$ 5 min.). Rocket experiments involve other limitations which preclude their use for certain measurements and usually make them extremely difficult to perform from a technical point of view. The limited size and weight which are possible, the high accelerations and unpredictable motions, and the difficulty of recovering data, all enter into the design of an experiment. The rocket vehicles in present use in the United States are the small 'Aerobee', the altitude range of which is being extended to about 180 km., and the very large 'Viking' rocket, which has already achieved an altitude record of 220 km. and may be expected to go to much greater heights eventually. Both these research rockets were developed under the auspices of the United States Navy to take the place of captured German *V*-2 rockets with which high-altitude research in the United States was started in 1946.

The trend for the future of sounding rockets will be towards higher altitudes; but for certain experiments the present altitudes are already sufficient, and the greatest handicap consists of the fact that rocket experiments, allowing for but a few minutes of observations, can only be made infrequently and, in general, only at a particular location. In this connexion Dr. Singer reflected on the probable state of ionospheric research or of geomagnetism, were those sciences similarly confined. In his opinion, the development of a rocket capable of long-time observations over a wide geographical range would overcome these fundamental limitations of sounding rockets. Such a rocket might even represent an economical solution of the problem when one considers the expense at present involved in the instrumentation and launching of some dozens of 'Aerobee' rockets. In order to set up an observing station to last at least for a few days, it would be necessary, of course, to place it into an orbit where it could exist for some time as an artificial satellite of the earth. Such a satellite rocket should be viewed mainly as an observatory for studying variations in the emission of solar radiation, both ultra-violet and X-ray; of solar corpuscles; and of the solar component of cosmic rays. Such studies may well constitute the important link necessary for a more complete understanding of the physics of the sun and of the sun's influence on the earth's atmosphere.

The theorist of the upper atmosphere is constantly faced with the necessity of effecting a reconciliation between the physical theories and vast amounts of sometimes uncertain experimental data, together with inferences about the solar spectrum. As Prof. D. R. Bates (Queen's University, Belfast) put it: "It has been said that it is comparatively easy to write a paper about any single aspect of the upper atmosphere, but practically impossible to write consistently about several". As an example he mentioned the problem of the temperature of the exosphere. This temperature can be computed from the known rate of escape of helium gas; one may also ask how this high temperature is maintained in the face of cooling by conduction and also by infra-red radiation from the ^3P-state of O I. If one invokes for this purpose an increase in the assumed ultra-violet emission of the sun, this in turn requires a re-interpretation of ionospheric observations.

One of the most fruitful lines has been the photochemical theory of the upper atmosphere, which seeks to account for chemical changes through the action of solar ultra-violet radiation. It has been particularly successful in explaining the formation and distribution of ozone. It has been used by Prof. S. Chapman and others to calculate the dissociation of the oxygen molecule; they have shown that, in the region above the 100-km. level, molecular oxygen must be completely broken down into atoms. The position concerning nitrogen is still the subject of controversy: on one hand, auroral spectra suggest that the molecular form is still abundant, even at altitudes of 500 miles; but, on the other hand, there is some observational evidence that dissociation into atoms is significant even at an altitude of about 100 km. Attempts have been made to calculate the relative abundances of the two forms of nitrogen at various levels from the rates of the various photochemical processes likely to be of importance, but these are so complicated that success has not yet been achieved. The time for equilibrium dissociation is found to be of the order of a few years, so that the local equilibrium depends very much on the dynamics of the atmospheric region. Hence any predictions based on static atmospheric models are likely to be incorrect. Similarly, the problem of chemical reactions of nitrogen is extremely difficult. For oxygen all the other gases present are inert, so that only four or five chemical reactions need be considered, whereas in the case of nitrogen molecules the oxygen enters into combination, thus leading to about thirty different chemical reactions.

Already the first measurements on the upper atmosphere have destroyed the old theory which pictured it in a state of hydrostatic equilibrium with hydrogen and helium predominant at the higher levels. Certainly new experimental findings will stimulate the theorist to try out new ideas, but Prof. Bates also reminded those present at the meeting that, in the case of the atmosphere, Eddington's famous advice, "never believe any observational results until they are confirmed by theory", is not without relevance.

The overall impression gained from these talks is that many of the fundamental features which affect the atmosphere are at present either unknown or roughly inferred. A particular point at issue is the ultra-violet and X-ray spectrum of the sun. Some rocket experiments have been made which have succeeded in measuring the spectrum down to about 2000 A. and have also obtained semi-quantitative information in some regions of the far ultra-violet and even X-radiation[2]. However, the technical difficulties of doing this work are very great. Besides this, it is known from the examination of ionosphere records that there exists a great variability in the ultra-violet emission from the sun, so that isolated rocket measurements may not give a representative picture of average conditions of the sun and of the

range of these conditions. It seems more likely that once one can relate certain features of the ionosphere with solar ultra-violet emission, one may be able to observe the sun by following changes of the ionospheric layers.

The position is more satisfactory with respect to the structure of the atmosphere. Recent rocket measurements[3] have given values of the temperature, density and pressure up to altitudes of about 220 km. The values up to 150 km. can be considered to be well established and are in rather good agreement with values deduced from meteor observations. In regard to the chemical composition of the atmosphere, first definite evidence that gravitational separation takes place near an altitude of 70 km. has been obtained from stratospheric air samples recovered with rocket-borne sampling-bottles and analysed in Prof. F. A. Paneth's laboratory[4]. It now seems important to confirm these results up to higher altitudes; there is every hope that present techniques can be extended to obtain measurements up to about 120 km. In this connexion Prof. Bates emphasized the great importance of human activity in affecting the abundance of certain minor gases in the atmosphere. He even suggested a new technique, namely, that of deliberately introducing certain rare components, like sodium, into the upper atmosphere in order to observe their photochemical reactions. One might expect rather large luminosities to arise from the conversion of stored-up photochemical energy by only small quantities of sodium.

In the discussions following the papers, Prof. K. G. Emeléus (Queen's University, Belfast) mentioned very briefly the relation of laboratory experiments on gas discharges to actual phenomena in the upper atmosphere. The great stumbling-block in laboratory experiments are the walls of the discharge tube and their effects on the phenomena to be studied. Dr. Singer brought out the point that in many cases the upper atmosphere itself provides a laboratory in which one can study certain physical phenomena. For example, the region of very high electrical conductivity found in the *E*-layer at the magnetic equator[5] strongly suggests the existence of 'boundaries', which could effectively be established by the horizontal magnetic field.

Some important conclusions on the state of the atmosphere above about 150 km. emerged from these stimulating discussions on the physics of the upper atmosphere. Below this level the atmosphere can be thought of as being in a static state; but above this altitude a dynamic picture seems to be necessary, since the static model no longer describes the actual phenomena. This transition was brought out especially clearly by the ionospheric results presented by Mr. Piggott; the differences between the lower and upper regions of the ionosphere are immediately apparent if one draws 'isophots' over the earth's surface: the *E*-layer shows a normal distribution, while the *F*-layer does not. This was emphasized further by the disagreement between photochemical theory and the observations of Dr. Roach, particularly the striking discrepancy in the height of the emitting layers. This non-equilibrium, dynamic condition above the *E*-layer in certain respects resembles tropospheric weather. It is a consequence, it was thought, of the long mean-free-paths, low collision probabilities and consequent long lifetimes of certain states, the low thermal capacity of the upper layers, and also the variability of the ultra-violet emission of the sun. In this connexion the value of isolated observations by rockets above altitudes of 200 km. appears doubtful. It would seem much more necessary to adopt the synoptic approach, as is used for ionospheric studies, particularly with regard to the study of ultra-violet radiation from the sun.

S. F. Singer

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DIFFERENTIATION OF VITAMIN B_{12} ACTIVE COMPOUNDS BY IONOPHORESIS AND MICROBIOLOGICAL ASSAY

FROM THE NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING, UNIVERSITY OF READING

Ionophoresis

By Dr. E. S. HOLDSWORTH

SINCE the isolation of vitamin B_{12} and other members of this group, several other compounds have been detected, related to but not in the cobalamin series. Wijmenga[1] isolated from pig fæces a crystalline substance he called vitamin B_{12m}; Ford and Porter[2] found vitamin B_{12}-like factors *A*, *B* and *C* in calf fæces, and isolated factor *A* in crystalline form; workers at Glaxo Laboratories (Lester Smith, private communication) have isolated in a fermentation process a factor, to our knowledge, identical with factor *B*; Pfiffner *et al.*[3] obtained pseudo-vitamin B_{12} and pseudo-vitamin B_{12b} from a rumen anaerobe; Lewis *et al.*[4] reported the presence of vitamin B_{12f} in rat fæces; Hausmann[5] has described further compounds, and other vitamin B_{12}-like compounds are being discovered. Dr. Pfiffner and Dr. Wijmenga kindly put at our disposal specimens of their compounds for comparison with those isolated by us.

In a study of these factors by paper chromatography with a number of different solvents, we noted that several had almost identical R_F values. Thus factor *A*, vitamin B_{12m} and the pseudo-vitamins B_{12} and B_{12b} could not be separated with the solvents usually employed. The ionophoresis of these substances on paper was then examined. In veronal/acetate buffers between *p*H 3·0 and 9·0, there was little advantage in the use of ionophoresis, since only factors *B* and *C* have appreciable mobility under these conditions, and these are easily distinguished chromatographically. However, the interesting observation was made that several of the factors when subjected to ionophoresis on paper using 2*N* acetic acid (*p*H 2·1) gave rise to multiple zones. Fig. 1 shows the findings after ionophoresis for 16 hr. at a potential gradient of 8 volts per cm. The atmosphere in the apparatus contained hydrogen cyanide in an attempt to retain the substances in the cyano-form, and the vitamins were revealed by the bioautographic technique described elsewhere[6]. Factor *A* and vitamin B_{12m} were alike in giving one main zone of the same mobility, accompanied by four

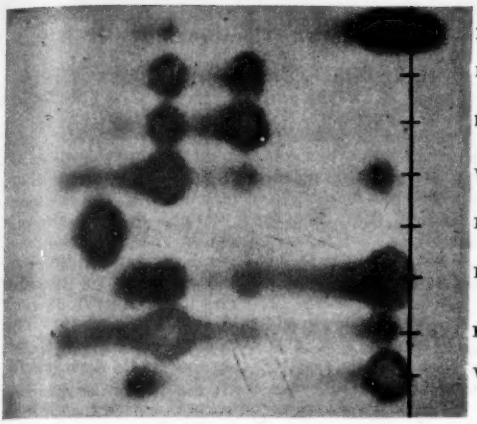

Fig. 1. Bioautograph using *Bact. coli*. Ionophoresis in 2*N* acetic acid for 16 hr. at 270 V.

others. Pseudo-vitamins B_{12} and B_{12b} each gave rise to two zones. A disadvantage of the bioautographic method for detecting activity is that the size of the bacterial growth-zone is proportional to the logarithm of the concentration of active substance, so that substances present only in traces are revealed; this explains why two spots were obtained from vitamin B_{12}, the more mobile spot probably representing vitamin B_{12b} formed by loss of the cyano-group. To avoid this complication, the substances were used in larger quantities (50–500 μgm.) to give visible pink spots, the concentration of acetic acid was reduced to 0·5 *N*, with 0·01 per cent potassium cyanide, and finally, the apparatus was protected from strong light. Under these conditions, vitamin B_{12} gave only one pink zone of zero mobility.

Factor *A* contained as major component a substance of mobility $3{\cdot}9 \times 10^{-5}$ cm.^{2} V.$^{-1}$ sec.$^{-1}$ as calculated by the method described by Kunkel and Tiselius[7], together with three minor components the positions of which suggested that they could be due to the presence in factor *A* of vitamin B_{12}, pseudo-vitamin B_{12} and factor *B* (Fig. 2, p. 151). With pseudo-vitamin B_{12} and pseudo-vitamin B_{12b} the major zone, of mobility $1{\cdot}5 \times 10^{-5}$ cm.^{2} V.$^{-1}$ sec.$^{-1}$, was preceded by a pink spot of the same mobility as factor *A* (Fig. 2). Pseudo-vitamin B_{12b} gave a third zone, brown in colour, of zero mobility and microbiologically almost inactive. By eluting each of the zones obtained from factor *A* and from the pseudo-vitamins B_{12} and B_{12b}, and subjecting each to repeated ionophoresis, the materials were obtained as single spots of the presumably pure substances. Vitamin B_{12m} was not available in sufficient amount to allow the separation of a visibly pink substance, but since it gave the same pattern of spots as factor *A* on the bioautograph (Fig. 1), there is reason to believe that vitamin B_{12m} contains the same major component as factor *A*, with pseudo-vitamin B_{12}, vitamin B_{12} and factor *B* as impurities. The same considerations suggest that factor *WR* obtained by Wijmenga[1] from ox liver is a mixture (Fig. 1). In cyanide extracts of the natural materials examined, we have so far been able to distinguish five substances having the following mobilities in 0·5 *N* acetic acid expressed as cm.^{2} V.$^{-1}$ sec.$^{-1}$: factor *A* (vitamin B_{12m}), $3{\cdot}9 \times 10^{-5}$; factor *B*, $5{\cdot}0 \times 10^{-5}$; factor *C*, $-1{\cdot}4 \times 10^{-5}$, that is, moving towards the anode; pseudo-vitamin B_{12}, $1{\cdot}5 \times 10^{-5}$; and vitamin B_{12}, with zero mobility.

An observation of practical importance made during the ionophoresis of the vitamin B_{12}-like substances is that ionophoresis may be applicable to other substances carrying very small electric charge. When the mobilities of the factors were compared in 0·5 *N* acetic acid and 0·1 *M* sodium acetate/hydrochloric acid buffer of the same *p*H, it was found that the mobilities in the buffer mixture were only about a third of those in acetic acid. If the acetic acid was made 0·2 *M* with respect to sodium chloride, sulphate or phosphate, without changing the *p*H of the solution, mobilities decreased. The polyvalent phosphate had the most effect, reducing mobilities almost to zero. Thus it is probable that the ionic strength of the conducting medium is the important factor, since it is known that a charged particle in solution acquires an atmosphere of oppositely charged ions, which have a retarding effect on the particle, the retarding effect increasing with increase in ionic strength[8]. Weak acids other than acetic (for example, phenylacetic and boric acids) can be used, and with a 0·5 *M* solution of boric acid, separations of the vitamin B_{12}-like substances can be obtained at a *p*H of 4·5 that cannot be obtained in the presence of strong electrolyte. Conducting solutions of low ionic strength must be used with caution, since they have very little buffering capacity and therefore the substances examined should be free from salts. Moreover, with increasing *p*H values, electro-osmosis becomes more marked and is a complicating factor in obtaining adequate separation.

Microbiological Tests

By J. E. FORD

We have shown that certain of the vitamin B_{12}-like compounds are differently active for different test organisms (cf. Ford[9]). In addition, each substance has different activities, relative to that of vitamin B_{12}, for the individual test organisms used in different assay techniques. The ratios of these different vitamin B_{12} activities are characteristic for each of the substances examined, and it was therefore possible to design differential assay procedures to provide evidence for their identity or otherwise.

Tests with Bacterium coli. A mutant of *Bacterium coli* requiring vitamin B_{12} was used in the tube-assay technique described by Burkholder[10]. The basal medium was modified by substituting thiomalic for thioglycollic acid.

Tests were also carried out using this organism in the cup-plate technique perfected by workers at the Glaxo Laboratories[11–13] using the same basal medium as in the tube assays.

Tests with Lactobacillus leichmannii ATCC 4797. With this organism we have used the method and medium described by Skeggs *et al.*[14], modified only in that the *p*H of the medium was adjusted to 5·5. Nucleotides were omitted from the medium; tubes were steamed for 30 min. before inoculating, and incubated for 60 hr. at 35° C.

Results. In Table 1 are set out results of differential assays of a number of vitamin B_{12}-active compounds. It is evident that factor *A* and vitamin B_{12m} have very similar microbiological activities, as have also the pseudo-vitamins B_{12} and B_{12b}. The two groups of compounds, however, are clearly different in their microbiological properties. Factors *B* and *WR* are different from each other and from the other two groups of substances. The results presented for factor *C* are only tentative, since this compound has not yet been prepared in pure form in significant amounts, and tests were carried out on a relatively crude concentrate. Optical densities at 361 mμ are included as an indication of the concentrations of the various substances.

Table 1. Relative Vitamin B_{12} Activities of Different Compounds, measured by Different Assay Techniques
Results are expressed in terms of the activities measured by the *Bacterium coli* tube-assay, given as 100 in each instance

Substance	Relative optical densities* at 361 mμ	*Bact. coli* tube-assay	*Bact. coli* plate-assay	*Lacto. leichmannii* tube-assay
Vitamin B_{12}	100	100	100	100
Factor *A*	204	100	267	83
Vitamin B_{12m}	238	100	282	91
Pseudo-vitamin B_{12}	560	100	700†	293
Pseudo-vitamin B_{12b}	525	100	525†	230
Factor *WR*	310,000‡	100	large 'fuzzy' zones	40,000‡
Factor *B*	1,350§	100	770	0·33
Factor *C*	not known	100	8,500	13·9

* Values are only very approximate. In some instances the amounts available for measurement were very small.
† Responses were markedly non-linear.
‡ This high figure reflects the low activity of factor *WR* in the *Bacterium coli* tube-assay.
§ The absorption maximum of this compound is, in fact, at 355 mμ.

In Table 2 are shown results obtained in the differential assay of certain components of these 'parent' compounds, obtained by ionophoresis in 0·5 *N* acetic acid as described in the first part of the paper.

Table 2. Relative Microbiological Activities of Components of Various Vitamin B_{12}-like Compounds obtained by Ionophoresis

'Parent' substance	Component	Ionophoretic mobility in 0·5 *N* acetic acid ($\mu \times 10^5$)	*Bact. coli* tube-assay	*Bact. coli* plate-assay	*Lacto. leichmannii* tube-assay
Factor *A*	Spot 3	3·9	100	274	64·4
Pseudo-vitamin B_{12}	Spot 2	3·9	100	264	68·0
Pseudo-vitamin B_{12}	Spot 1	1·5	100	1,400*	425
Factor *A*	Spot 2	1·5	100	1,000*	375
Factor *B*	Factor *B*	5·0	100	580	<0·3

* Responses were markedly non-linear

It is clear that the major component of factor *A*, its 'spot 3', is not distinguishable by these tests from the minor component of pseudo-vitamin B_{12}, its 'spot 2'. In the same way, the major component of pseudo-vitamin B_{12}, its 'spot 1', is not distinguishable from a minor component of factor *A*, its 'spot 2'.

There is evidence from bioautographs that factor *WR* contains, in addition to its several vitamin B_{12}-active components (see Fig. 1), a further substance inhibiting the growth of *Bacterium coli*. The presence of this inhibitor no doubt explains the low activity of the compound for this test organism.

Occurrence of the Various Vitamin B_{12} Active Compounds

By J. E. Ford, Dr. E. S. Holdsworth, Dr. S. K. Kon and Dr. J. W. G. Porter

The ionophoretic and microbiological findings just described show that compounds formerly accepted as pure were not, in fact, pure. We interpret our findings as proof that factor *A* and vitamin B_{12m} are not pure substances, but that they contain the same major component. Similarly, pseudo-vitamins B_{12} and B_{12b} owe their activity to a common major component, different from that of factor *A* (or vitamin B_{12m}), and to factor *A*. The lower microbiological potencies of pseudo-vitamin B_{12b} are probably due to the presence in it of a third component detected by ionophoresis (Fig. 2) that has little activity for micro-organisms.

Vitamin B_{12}[4], from our experience with vitamin B_{12}-active compounds from rat fæces (see below), may possibly be a mixture of factor *A* and pseudo-vitamin B_{12}. Factor *WR*[1] from beef liver contains factor *A*, pseudo-vitamin B_{12} and vitamin B_{12}, and is interesting in that it indicates that factors other than vitamin B_{12} can appear in small amounts in the liver of ruminants (cf. Ford *et al.*[15]). Further, we have found that the vitamin B_{12} activity of cow urine is largely contributed by substances other than vitamin B_{12} (unpublished).

We have estimated the relative amounts of the different vitamin B_{12}-active compounds in the fæces of calves, rats and rabbits. Chromatography of extracts of all these materials showed a broadly similar distribution of activity: the main component being fraction *A* with small contributions from factors *B*, *C* and vitamin B_{12}. The fraction *A* component from each extract was repeatedly chromatographed until it appeared homogeneous: subsequent ionophoresis in 0·5 *N* acetic acid separated the apparently homogeneous fraction *A* component from calf fæces into factor *A* with some pseudo-vitamin B_{12} and a trace of vitamin B_{12}; the fraction *A* component from rat fæces yielded approximately equal amounts of factor *A* and pseudo-vitamin B_{12}; and that from rabbit fæces yielded factor *A* and only a trace of pseudo-vitamin B_{12}.

In the light of these findings we now consider that the vitamin B_{12}-activity for micro-organisms of extracts of gut contents and fæces, prepared in the presence of cyanide, is contributed in varying proportions by the following five substances: factors *A* (vitamin B_{12m}), *B* and *C*, pseudo-vitamin B_{12} and vitamin B_{12} itself. In natural materials these compounds may exist in both free and combined forms (see also ref. 5).

The facts that these compounds act as alternative growth-factors for several micro-organisms, and that in extracts of *Bacterium coli* cells grown in a peptone medium all five compounds are present, suggest their close structural similarity.

The difficulty of separating these vitamin B_{12}-like compounds in a pure state by chromatography, and the relative ease with which chromatographically homogeneous though impure compounds crystallize (for example, factor *A*, vitamin B_{12m} and pseudo-vitamin B_{12}), may give rise to a number of spurious new 'substances' with similar though not identical properties. Such new 'substances' are likely to be isolated during the fractionation of the vitamin B_{12} activity of natural materials unless ionophoretic

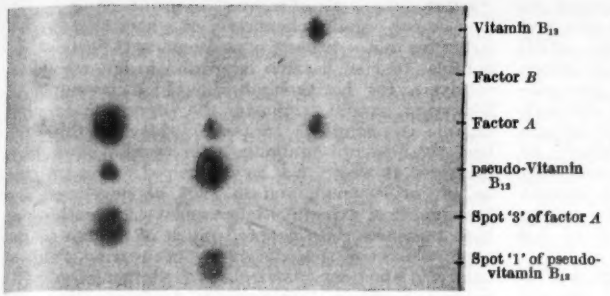

Fig. 2. Visibly pink amounts of the factors after ionophoresis in 0·5*N* acetic acid for 16 hr. at 270 V. Movement of vitamin B_{12} was due to electro-osmosis

techniques, which are more selective than those of chromatography, are used for their resolution.

As these vitamin B_{12}-active compounds are formed by microbial synthesis in the rumen or in the large intestine or in both, it is probable that the relative amounts of each that appear in gut contents depend on the composition of the microbial flora. This is known to be, to some extent, governed by the composition of the diet, so that even within one species it is likely that the relative amounts of each of these factors will vary with the nature of the diet.

We should again like to thank Dr. Pfiffner and Dr. Wijmenga for their generosity in allowing us to examine their compounds, and to publish our findings. The interpretation of the results is solely ours; the conclusions may not represent the views of Dr. Pfiffner or Dr. Wijmenga and do not bind them in any way. [Dec. 3.

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OBITUARIES

Prof. M. G. Evans, F.R.S.

PHYSICAL chemists all over the world will have learned with sorrow of the untimely death of Prof. M. G. Evans. A graduate of the University of Manchester, Evans was appointed to the staff of the University in 1926, and after spending a year with a Rockefeller fellowship at Princeton, he was appointed to the chair of inorganic and physical chemistry in the University of Leeds in 1939. While at Leeds he established an international reputation for his work on the fundamental processes occurring in chemical reactions, and was elected a Fellow of the Royal Society in 1947. In 1948 he returned to Manchester to the chair of physical chemistry, and had already established a flourishing research school there when his scientific work was so tragically brought to its close.

Evans occupied a unique position in English physical chemistry. His versatile and flexible mind endowed him with a remarkable capacity for grasping the essentials of any scientific problem which was presented to him. All those who had the opportunity of working with him were astonished at his ability to state their problems for them in clear, exact and illuminating language, and there was no better cure for the all too common complaint of 'getting stuck' than to go and have a chat with 'M. G.', as he was known to all his friends. Evans's inspired common sense was the secret of his scientific success, both in his own work and in guiding the research of others.

Evans was one of the early pioneers of the transition state theory, applying it to quite complicated chemical reactions; and it was largely his inspiration which led to the modern theory of unimolecular reactions. His work on the initiation of polymerization led to important technical advances, and in more recent years he clarified in an elegant way the nature of the electronic processes occurring in oxidation and reduction. The papers of Evans and his school on the so-called electron-transfer reactions are classics in that field. Possibly less well known but no less penetrating were his contributions to applied wave mechanics and the statistical mechanics of surfaces, and one of his most important contributions to the theory of bond dissociation energies was made only just before his death. The 1953 Jubilee Discussion of the Faraday Society on "Solutions of Non-electrolytes" was originally conceived by Evans.

Outstanding as a physical chemist, M. G. Evans was equally outstanding as a person. His industry and great ability were matched only by his extraordinary modesty and a personal charm which won him the affection, as well as the admiration, of all those who had the good fortune to meet him. He combined without affectation the hard-headedness of a scientific administrator and the subtlety and sensitivity of a creative artist. His nomination to the Government's Advisory Council on Scientific Policy and to the Scientific Advisory Council of the Ministry of Supply imposed on him a heavy burden of additional responsibility. Nevertheless, in spite of the severe strain to which he undoubtedly subjected himself, Evans was always ready to help those who came to see him with scientific or personal problems, and there will be many of his friends who will sadly miss his wise and sympathetic counsel.

H. C. LONGUET-HIGGINS

Prof. V. N. Ipatieff

PROF. VLADIMIR NIKOLAEVICH IPATIEFF died in Chicago on November 29, 1952, just one week after his eighty-fifth birthday. Few men of science in our times have had more remarkable careers.

Born in Moscow in 1867, he attended a series of military schools and graduated from the Michaelovsky

Artillery School in 1892. He had developed an interest in chemistry several years before this and established a private laboratory from his small earnings; because of the nature of the curriculum and the instruction, most of his chemistry was self-taught. He remained at the Michaelovsky Artillery School as an instructor in chemistry and later became its first professor of chemistry. During 1895–97 he was sent to Western Europe, where he studied with von Baeyer in Munich and with Vielle and Sarraut in Paris, and in 1907 the chair of chemistry in the University of St. Petersburg was added to his duties.

During the First World War, Ipatieff was a lieutenant-general in charge of the Russian chemical industry, and because of his distinction he continued to hold high office during the Soviet regime. From 1921 until 1926 he was a member of the Supreme Economic Council of the Soviet Union, and in 1927 an institute for the study of high-pressure reactions was established for him. However, the scientific climate was increasingly distasteful to him and, in the company of his wife, he managed to leave Russia. After a short stay in Germany, he went to the United States in 1931 to become a lecturer in chemistry at the Northwestern University, Evanston, Ill., and director of research at the Universal Oil Products Co. In 1938, in order more easily to pursue purely academic research and to be able to teach his techniques to students, he established the Ipatieff High-Pressure Laboratory at the Northwestern University with the support of the Universal Oil Products Co., and he was actively engaged in his positions at the University and with the Company until two weeks before his death.

Commencing his career in the United States at an age when most men retire, Ipatieff published thereafter about a hundred and fifty scientific papers and obtained more than two hundred patents. He had already published some two hundred papers before he left Russia, starting with one in 1892, "Chemical Investigation of the Structure of Steel". The many honours that he received are too numerous to enumerate here, but mention should be made of the fact that he was the only man to have held regular membership in the national academies of science of both the U.S.S.R. and the United States (though his membership in the former, along with all other Russian honours, was cancelled by the Soviet Government in 1936 following his repeated refusal to return to the U.S.S.R. His wife, Barbara Demitrievna, with whom he had celebrated in 1952 their sixtieth wedding anniversary, survived him but a few days and died on December 9. Of their children, a son and a daughter still live in the U.S.S.R., one son was killed in the First World War and another lost his life while fighting tropical fevers in the Belgian Congo.

Ipatieff was a man of charm and kindness who enjoyed social contacts. He was always ready with encouragement and assistance to anyone interested in advancing science. He was an indefatigable worker who set himself a hard schedule, any disturbance to which upset him, and in particular his rare illnesses especially outraged his sense of order. While his life was primarily devoted to science, he had a number of other interests. He was a devout member of the Russian Orthodox Church, though no narrow sectarian, and he read widely in literature. In his earlier days he was an expert rider; fishing and swimming mainly occupied his vacations until a few years ago, and he was a great walker.

After some work of interest in ordnance and some in classical organic chemistry, of which that on the structure and synthesis of isoprene was particularly notable, Ipatieff became interested in heterogeneous catalysis, for he thought that high pressures of hydrogen would facilitate the hydrogenation of organic compounds. In testing this hypothesis he had to develop equipment for working at high pressures, in which task he was helped by his training as an artilleryman, and in 1903 he developed the first practical experimental autoclave for working at high pressures. He devoted much of his life to the exploitation of this discovery in a wide field of catalytic reactions, particularly hydrogenation. His pioneer work in high-pressure hydrogenation had revolutionary effects upon laboratory and technical procedures in many fields of chemistry. He was the first to recognize the use of promoters in heterogeneous catalysis. His work in the United States is notable for the discovery of the 'solid phosphoric acid' catalysis for the polymerization of olefines, for the discovery of the alkylation of olefines by *iso*paraffins and for work in the isomerization of alkanes. His research was one of the main sources of the revival of interest in hydrocarbon chemistry and of aliphatic chemistry in general and may be considered as the origin of much of modern petroleum technology.

Several months ago the Universal Oil Products Co. entered into negotiations with Northwestern University to establish the Vladimir Ipatieff research professorship, by which the Company will grant the University 25,000 dollars annually for the salaries of the professor and an assistant and for other expenses. It is a source of much gratification that Ipatieff had been informed of the final details of this professorship a few days before his death.

Robert L. Burwell, jun.

Dr. K. G. Blair

Kenneth Gloyne Blair, who at the time of his retirement was a deputy keeper of the Department of Entomology of the British Museum (Natural History), died at Freshwater, Isle of Wight, on December 11. Born at Nottingham on December 22, 1882, he was educated at Highgate School and Birkbeck College, London. After a brief period spent in other government offices, he transferred in 1910 to the Natural History Museum, being appointed assistant in the Department of Zoology, which then included entomology.

Under Dr. C. J. Gahan, Blair was put in charge of a large section of the Coleoptera comprising principally the Heteromera, which had perforce been largely neglected for many years. His systematic overhaul of these collections resulted in the publication of numerous papers concerned with the critical revision of genera and species, the description of new ones, the elucidation of the work of the early authors, a catalogue of the Pythidæ and Pyrochroidæ, and so on. Concurrently he published many papers of faunistic interest, based largely on collections made by various expeditions. These ranged from Mt. Everest, Krakatau, Samoa, Fiji, the Mentawi Islands, Christmas Island and the Marquesas in the East, through southern Arabia and South Africa to the Galapagos Islands.

But it would be wrong to base any estimation of Blair's contributions to entomology solely on the

evidence of these works. He was at his best in the field among living insects, where he had a quite amazing flair for the 'good thing' and in consequence added considerably to our knowledge of the British fauna in nearly all orders of insects. Insect luminosity, and the complex inter-relationships of the inhabitants of plant galls, fascinated him and were the subject of several papers; fossil insects, myrmecophiles, insect stridulation and the morphology of beetle larvæ also attracted his attention. Up to the time of his retirement, due to ill health attributable to service with the Seaforth Highlanders during the First World War, he took a most active part in the proceedings of the societies to which he belonged. He was president of the South London Natural History Society in 1920, 1921 and 1931 and of the Royal Entomological Society during 1940–41. He is mourned by a very wide circle of friends, who will always remember gratefully the help he gave so freely and modestly to all who sought it, from his unusually wide store of knowledge and experience.

N. D. RILEY

Mr. E. G. Dymond

EDMUND GILBERT DYMOND died suddenly in Edinburgh on October 26. He was born at Hairwain, South Wales, in which town his father was engaged in business as a civil engineer. Between the ages of twelve and eighteen persistent ill-health made regular schooling impossible, but at the latter age he entered St. John's College, Cambridge, and thereafter lived an active and productive life. Only his early death reminded his friends that his energy and enthusiasm must often have outmatched his strength.

Dymond obtained first-class honours in physics in Part 2 of the Natural Sciences Tripos in 1922, and was awarded a Hutchinson research studentship by St. John's. In 1925 his College elected him to a fellowship. He had spent two of the intervening years in research at the Cavendish Laboratory, and the third as International Education Board Fellow at Göttingen. The following year he spent in Princeton. During the whole of this time, and throughout the next five years, when he was back in Cambridge, Dymond investigated various problems of electron collisions in gases.

In 1932 Dymond moved to Edinburgh, first as Carnegie Teaching Fellow, then as lecturer, and after 1948 as reader in natural philosophy. Soon afterwards his main research interest changed, and as a member of the Wordie expedition to North-West Greenland in 1937 he obtained records of cosmic ray intensity, using balloon-borne apparatus up to a height of about twelve miles. About the same time he released his first balloons from the Edinburgh district in similar investigations. This work remained interrupted throughout the Second World War, but Dymond continued his contribution to upper-atmosphere physics at Kew Observatory, where he developed and perfected the British *radio-sonde*. He returned to Edinburgh in 1946.

Building up equipment again after the War, and gathering a small research team around him, he was favourably placed to add considerably to our knowledge not only of cosmic radiation at great heights, but also of ozone distribution. However, only one major investigation was complete at the time of his death. The progress of the others will be slower for lack of his direction.

N. FEATHER

Prof. L. Lapicque

COLLEAGUES and friends in every country will regret the death, at the age of eighty-six, of Louis Lapicque, professor at the Sorbonne during 1919–36 and the leading figure in French physiology. His early researches were biochemical and they were followed by an expedition to the Andaman Islands to collect anthropological data; but in 1902, after his return to France, he took up the studies of excitability in nerve and muscle for which he became famous.

Lapicque used new methods to explore the relation between the duration and the strength of an effective electric stimulus: his curves showed the inadequacy of Nernst's treatment and led to new ideas based on the measurement of the 'chronaxie', a quantity giving the time factor of the excitation process. In collaboration with Mme. Lapicque he studied the chronaxie relations of a wide variety of tissues and demonstrated their essential similarity. The theory of isochronism which he afterwards developed may not have had all the far-reaching implications suggested by it, but his ingenious experiments and trenchant exposition have a classical quality which will be long remembered.

Between the two World Wars, Prof. Lapicque played a decisive part in the development of physiology in France. He was a welcome figure at international gatherings, where he spoke lucidly and with conviction on the problems of scientific co-operation. Vigorous in body as in mind, a keen yachtsman and a charming host, he was a worthy representative of the great traditions of his country.

E. D. ADRIAN

NEWS and VIEWS

Chair of Mining in the Imperial College, London: Prof. J. A. S. Ritson

PROF. J. A. S. RITSON vacated the University of London chair of mining at the Royal School of Mines, Imperial College, in October 1952, after a distinguished tenure of seventeen years. He is a graduate of the University of Durham, and started his professional career as inspector of mines in the Scottish, Yorkshire and South Wales coalfields. After distinguished service in the Army during the First World War he occupied the chair of mining in the University of Leeds during 1923–35, where he devoted much of his research to the improvement of mine rescue appliances and shot-firing techniques. Since his appointment to the Royal School of Mines, Prof. Ritson has maintained his keen interest in coal mining, and rapidly gained a high reputation as an expert on problems of metalliferous mining, based on experience won in various parts of the world. Among his multifarious duties he has acted for many years as Crown mineral agent, as a member of the Coal Commission, and as deputy chairman of the Mineral Resources Committee of the Ministry of Fuel and Power; during the Second World War he joined that Ministry for a

few years as director of mining supplies and director of production. He served two sessions as president of the Institution of Mining Engineers and is now president-elect of the Institution of Mining and Metallurgy. Prof. Ritson has always been intensely interested in the education and training of mining engineers, and has played a leading part during recent years in organizing the expansion and intensification of courses in mining and mineral dressing at the Royal School of Mines.

Prof. J. C. Mitcheson

Prof. J. C. Mitcheson, who has succeeded Prof. Ritson in the Royal School of Mines, comes of a family long distinguished for its outstanding services to the mining industry in the Midlands coalfields. After graduating at the University of Birmingham, he acted there for a year as lecturer in coal mining and demonstrator in mines rescue, before joining his father's consulting practice in Stoke-on-Trent in 1924. Afterwards he spent many years as agent and later as managing director of the Birch Coppice Collieries, near Tamworth, one of the largest collieries in the Warwickshire Coalfield. After serving as director of production for this coalfield, under the Ministry of Fuel and Power, he was appointed divisional chief planning engineer of the West Midlands Division, National Coal Board, returning in 1947 to practice as consulting mining engineer. During his twenty years experience in the management of collieries, he has been closely associated with research in mining and has pioneered many new methods of fuel efficiency, machine mining, coal preparation, underground lighting, accident prevention and roof control. Throughout this period he has served assiduously as a member or chairman of various education and training committees in the Warwickshire Coalfield. At the present time he is on the Mining Qualifications Board and the Safety in Mines Research Board set up by the Ministry of Fuel and Power, besides being intimately concerned with the new national certificate schemes for the mining industry. It is a happy augury that he should succeed to the chair of mining at the Royal School of Mines while serving as president of the Institution of Mining Engineers.

Wilfred Hall Telescope

The 15-in. visual refractor, with 15-in. photographic refractor attached, which formed the principal equipment of the late Dr. Wilfred Hall's private observatory near Newcastle, is now the subject of a bequest which it is proving regrettably difficult to accept. It was bequeathed in the first instance to the British Astronomical Association, and failing acceptance by the Association to the Royal Astronomical Society, provided that they "make use of it or cause it to be made use of on such terms and conditions as they may see fit, in some place chosen by them where in their opinion it can be of service to scientific research"; but it is estimated that to set it up will cost between two and three thousand pounds, even allowing for the fact that the will provides £500 towards the cost of removal—it cannot stay where it is.

It seems clear that only some permanent authority could properly be entrusted with such a long-term responsibility as this telescope must represent; if it is hard to find the money once, no scheme can be considered which would imply having to find it repeatedly, and a permanent loan to some educational body seems inevitable. The British Astronomical Association has been in touch with one body which hoped to pay half the cost, but after careful study it was decided that the number of members of the Association who would make any serious use of the telescope was too small, at any one site, to justify providing even half the cost from the Association's limited resources; it has therefore refused the bequest. It seems improbable that the Royal Astronomical Society could accept any financial liability either, and the telescope can thus be saved from the dealers' hands only if the entire cost of installation can be raised in some other way, before the Royal Astronomical Society in its turn refuses the offer. If the telescope is sold, the proceeds revert to Dr. Hall's estate. The will does not appear to demand that if accepted it shall be used purely for research, nor is it conspicuously a modern research tool. It could tackle certain tasks, and at the same time could introduce a number of people to some of the subjects and methods of research, and add greatly to a general knowledge of astronomy in its neighbourhood. It is to be hoped that some way may be found of grasping the opportunity that has arisen.

World Power Conference: Annual Report for 1951

The annual report for 1951 of the World Power Conference (pp. 32; from 201 Grand Buildings, London, W.C.2; 1952; 1*s.* 6*d.*) records a membership of forty countries, in thirty-seven of which National Committees have been formed; the German Federal Republic and Japan were admitted to membership at the July 1951 meeting of the international executive council. A brief chronicle of the sectional meeting held in New Delhi during January 10–16, 1951, is appended to the report; the technical sessions were held concurrently with sessions of the Fourth Congress of the International Commission on Large Dams and the First Congress of the International Commission on Irrigation and Drainage. The bound transactions of the former meeting have recently been published. An invitation to hold a sectional meeting in Rio de Janeiro during July–August 1954 was accepted by the international executive council, and an outline of the technical programme for this meeting is also appended: the topics to be discussed centre around the special energy problems of the tropical and sub-tropical countries. A report on the work of the World Power Conference in the field of water control and utilization was prepared for the secretariat of the Economic and Social Council of the United Nations. Statistical Year-book No. 6 of the World Power Conference is in the process of being published. A list of publications, issued or to be issued under the auspices of the international executive council, is also appended. At the annual general meeting of the British National Committee, Sir John Hacking was elected vice-chairman and Mr. F. G. Brewer honorary treasurer, in succession to Mr. H. Hobson and Colonel C. M. Croft, respectively.

Pedo-botanical Surveys in the Belgian Congo

The study of soils and the associated vegetation is now one of the principal tasks of the Institut National pour l'Étude Agronomique du Congo Belge (I.N.E.A.C.). A recent report ("Les Associations Végétales de la Plaine de la Ruzizi (Congo Belge) en Relation avec le Milieu". Publ. I.N.E.A.C., Sér. Sci. No. 52, pp. 1–321, 1952; 180 fr.), by R. Germain, deals with a pedo-botanical survey of the Ruzizi

plain, the extensive and varied alluvial territory that lies between Lakes Kivu and Tanganyika. The physical environment, the flora, the several habitats —some nine, ranging from aquatic to forest paraclimax, are indicated—and their floristic associations are described in detail and illustrated by graphs and numerous excellent photographs. The plain is floristically rich, with 877 species of seed plants and pteridophytes, comprising 427 genera and 99 families. There is a marked dominance of species of the basic Sudanese–Zambesian flora (42·6 per cent) with 6 per cent of foreign species, chiefly from the west, the balance being transitional and widely distributed species.

Electron Microscope and Microdissection

UNDER this title, R. Bovey (*J. Roy. Micro. Soc.*, Ser. III, **72**, 56; 1952) has described and illustrated a new technique for preparing biological specimens for study with the electron microscope. Using the de Fonbrune micromanipulator and an inverted microscope, the microdissection is made directly on a collodion film, or a film of 'Formvar', supported by a thin coverslip. The specimen is afterwards mounted on a grid. It is shown that the technique described can be successfully applied to the study of nuclear and cellular membranes and similar materials.

Microbial Growth and its Inhibition

EIGHTEEN of the papers presented at the First International Symposium on Chemical Microbiology, which was held in Rome during June 1951, have been brought together under the title "Microbial Growth and its Inhibition" in No. 10 of the World Health Organization Monograph Series (pp. 285. Geneva: W.H.O.; London: H.M.S.O., 1952. 15*s.*, 3 dollars or 12 Sw. francs); the papers had been previously published in the *Bulletin* of the World Health Organization. Many of the communications deal with the production, chemistry and testing of antibiotics, while problems of resistance are discussed by M. Welsch and L. L. Cavalli. The lag phase in the growth of *Pasteurella pestis* is investigated by S. S. Sokhey, and B. C. J. G. Knight discusses the physiological background to problems of growth inhibition. The role of the B group of vitamins in biosynthetic processes is dealt with by D. D. Woods, with particular reference to the metabolic functions of folic acid and B_{12}, and J. Monod presents his investigations concerning the specific inhibitors and inducers involved in the production of β-galactosidase in *Escherichia coli*. The collection of papers represents in general a number of contributions on specific aspects of microbial growth and of the properties of substances inhibiting such growth, rather than an outline or synthesis of present knowledge. Discussions are not published, but each paper concludes with useful summaries in both English and French.

Centrifuges and *p*H Meters

A SURVEY of the requirements of biologists using centrifuges and *p*H meters has been made by the Institute of Biology. The analyses of the views expressed are given in two reports, which have been sent to all who collaborated in the survey and to all British manufacturers of the instruments. It is hoped that this presentation of the collected views of biologists, by making clear those features which are desirable but often lacking and the defects now experienced by users, will enable manufacturers to introduce the necessary modifications to existing models and to design future instruments to meet the expressed needs. Copies of the reports can be obtained from the General Secretary, Institute of Biology, Tavistock House South, Tavistock Square, W.C.1.

A.S.T.M. Index of X-Ray Powder Diffraction Data

THE index, prepared by the American Society for Testing Materials, of X-ray powder diffraction data, widely known as the A.S.T.M. Index, has now been in use for about ten years, and it is recognized that it contains a number of wrong identifications which are likely to lead to confusion. The X-ray Analysis Group of the Institute of Physics therefore proposes to collect information on the errors which have been observed by users of the Index, and to publish as soon as possible in some suitable way a list of all those errors which seem to be substantiated. It is believed that many, if not all, of these errors have by now been noted by various workers and may in some cases have been mentioned casually in their publications; but in order to be of real use to others it is necessary that they should all be published collectively. Accordingly, everyone who has noted such errors is asked, whether he has already published them or not, to send the details to Dr. A. J. C. Wilson, University College, Cathays Park, Cardiff.

Development of Mineral Resources in the United States

A PANEL of specialists in geology, mining and geophysics representing industry, government and the universities in the United States has been established to advise the National Science Foundation on policy questions connected with the recommendations of the President's Materials Policy Commission for development of the mineral resources of the nation. The first meeting of the panel was held in Washington, D.C., on November 29, 1952. In its report, the Commission recommended that "an intensive program of basic scientific research and technical development be undertaken on techniques and instruments of exploration for minerals", and the advisory panel of the Foundation will consider the need for an inventory of current research in exploration techniques and the formation of a committee to make such an inventory.

Nineteenth International Physiological Congress, Montreal

THE Nineteenth International Physiological Congress will be held in Montreal during August 31–September 4, 1953, and one of the main concerns of the organizers of the Congress is to ensure that an adequate number of scientific workers from overseas countries will attend, despite the relatively heavy financial expenses that must necessarily be incurred by such participants. Physiologists, biochemists, pharmacologists and others from outside Canada and the United States who hope to attend the Congress are therefore asked to notify the secretaries of their national societies of that fact as soon as possible. This will aid the Congress organizers in arranging for special lectures and discussions to be held in the United States and Canada during the weeks preceding and following the Congress; it is hoped that those from overseas who are invited to take part in such functions will, in some cases at least, receive financial help that will appreciably reduce the cost of attending the Congress itself. Those who live in countries where there are no national scientific societies, and who hope to attend the Congress, should write directly to the executive secretary of

the Congress at McGill University, Montreal. Arrangements are being made for an exhibition of scientific instruments and books at the Congress, and representatives of firms who wish to reserve space at this exhibition should write to the exhibit manager, Mr. Steven K. Herlitz, 280 Madison Avenue, New York, N.Y.

Education in Chemistry : Discussion in London

A discussion on "Education in Chemistry", under the joint auspices of the London Sections of the British Association of Chemists and of the Royal Institute of Chemistry, will be held at 6.30 p.m. on February 18 at the Wellcome Research Institution, 183 Euston Road, London, N.W.1. The principal speakers will be Prof. C. K. Ingold, professor of chemistry, University College, London; Dr. J. W. Skellon, head of the Department of Chemistry, Acton Technical College; Dr. O. L. Brady, reader in organic chemistry, University College, London; Mr. R. W. Blount, chief inspector, Ministry of Education; and Dr. Norman Booth, research manager, British Oxygen Co., Ltd. Five themes to be covered will be: the aim of the revised regulations in science; external degrees in science; professional qualifications in chemistry; National Certificate in chemistry; and requirements of industry. Visitors are welcome to the meeting, and those who intend to participate in the general discussion should inform one of the secretaries, either F. C. Hymas, honorary secretary of the London Section, Royal Institute of Chemistry, 30 Russell Square, London, W.1, or T. Bewley, honorary secretary of the London Section, British Association of Chemists, Hinchley House, 14 Harley Street, London, W.1.

Physical Society : Meeting in Leeds on Solid-state Physics

The spring provincial meeting of the Physical Society will be held in the Department of Physics, University of Leeds, during March 30–April 1. The subject of the meeting, "Aspects of Solid-state Physics", will be divided into three sessions as follows: analysis of magnetization curves; band theory of metals; and ferroelectricity and luminescence. Papers will be read by the following: A. F. Devonshire (University of Bristol); E. W. Elcock, J. Ewles, F. E. Hoare, K. Hunt, P. Rhodes, E. C. Stoner and R. S. Tebble (University of Leeds); H. Jones and E. P. Wohlfarth (Imperial College of Science and Technology, London); L. F. Bates (University of Nottingham); E. E. Schneider (King's College, Newcastle upon Tyne); W. Sucksmith (University of Sheffield). Non-members of the Society are welcome to attend the meeting, but must apply before March 9 to the offices of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, where all further particulars can be obtained.

Institute of Biology : London Meetings

The Institute of Biology is holding three meetings in London, which are experimental in nature, one purpose being to determine whether there is adequate support for the formation of a London branch of the Institute on a permanent basis. They are experimental also in their form and subject; for example, it is thought that some future meetings might be held jointly with other societies, and that the formation of study groups might be considered. The first meeting, an illustrated talk by Dr. N. Tinbergen, reader in animal behaviour, University of Oxford, on "The Functions and Causation of Animal Courtship", was held on January 22. The other two are as follows: a whole-day visit on February 21 to the Zoological Gardens, Regent's Park; and a meeting on "Setting about Research for Oneself", to be held at 7.30 p.m. on March 26, at the Society for Visiting Scientists, 5 Old Burlington Street, London, W.1, at which the principal speakers will be Dr. T. E. Wallis (sometime reader in pharmacognosy, University of London), Dr. W. B. Turrill (keeper, Herbarium, Kew), G. A. Steven (fisheries naturalist, Marine Laboratory, Plymouth) and Dr. P. Alexander (Chemistry Department, Imperial College of Science and Technology). The visit to the Zoo, for which a fee of 7*s*., inclusive of luncheon, will be charged, is restricted to members of the Institute only, and application should be made to D. Wragge Morley, 47 Downshire Hill, London, N.W.3. For the third meeting, members may bring guests. Further information can be obtained from the Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

Announcements

King's College of Household and Social Science, University of London, has been granted by H.M. The Queen a royal charter of incorporation as Queen Elizabeth College.

Dr. T. E. Allibone, director of the Research Laboratory of the Associated Electrical Industries, Aldermaston, Berks, has also been appointed director of research to the Edison Swan Electric Co. and to the board of that Company.

Appointments to chairs in University College, Dublin (National University of Ireland), have been made as follows: Dr. T. E. Nevin (experimental physics); Mr. P. E. Mullaney (veterinary pathology and bacteriology); Mr. W. R. Kelly (veterinary medicine and meat inspection).

The following staff changes in the University of Leeds have been announced: K. L. Butcher has been appointed Brotherton lecturer in chemical engineering; Dr. J. P. Danby, lecturer in the Department of Leather Industries, and Dr. B. D. Wyke, lecturer in the Department of Physiology, have resigned their posts.

Australian National University scholarships for work in the University's Department of Nuclear Physics under Prof. E. W. Titterton have been awarded to the following graduates: Mr. A. J. F. Boyle (University of Melbourne), Mr. H. J. Hay (University of Otago, N.Z.), Mr. D. W. Smellie (University of British Columbia), and Mr. A. C. Riviere (University of Western Australia, now at the National Physical Laboratory, Teddington). The scholars will take up residence in Canberra at the commencement of the Australian academic year.

The American Society for the Study of Sterility is offering a prize of a thousand dollars for the most outstanding contribution to the subject of infertility and sterility. Entries for the prize must consist of an essay based on research in this field, and all essays must be received not later than March 1. Further details of the competition can be obtained from the Society, c/o Dr. Herbert H. Thomas, 920 South 19th Street, Birmingham, Alabama.

Erratum. In the title of the letter by Eileen L. Blackall and Prof. E. D. Hughes in *Nature*, **170**, 972 (1952), for "*C*-Nitration" read "*O*-Nitration".

RESEARCH IN BRITISH COLONIAL TERRITORIES*

ALL the main research schemes in progress under the Colonial Medical Research Committee were continued during 1951–52, and its seventh annual report records the filling of thirteen vacancies, although recruitment still lags behind requirements. A malaria-research scheme in Jamaica was concluded and established, with similar objectives, in the Gold Coast. A small grant was made towards a new project, an investigation of goitre in Nigeria. Two regional standing advisory committees for medical research have recently been instituted in East and in West Africa, respectively, to advise on the needs and priorities for medical research in these regions and to promote the co-ordination of current research activities within the region and with research workers in the United Kingdom. Under the East African Medical Survey, which is intended to be in three phases, work has been commenced on Ukara Island on Lake Victoria, an area chosen because of the poverty of the land and people, and of the possibility later of attempting eradication of malaria vectors. Here the collection of reliable vital statistics and information on the health and sickness of the population has been finished and has shown that the major problems are not medical. Bukoba, on Lake Victoria, was chosen for study because it is peopled by a wealthy tribe thought to be dying out because of a high incidence of venereal disease, and Kurimba, Tanganyika, because of the high incidence of schistosomiasis and of the possibility of integrating the findings with those of an intensive agricultural survey in progress.

The filariasis project in East Africa, although handicapped by shortage of staff, has shown that bancroftian filariasis here appears to cause no inconvenience to most infected individuals and produces no symptom-complex like the 'mumu' of the Pacific. The incidence of late complications like elephantiasis is related to the intensity of infection in any area, as distinct from the incidence. Studies on the chemotherapy of malaria in Malaya have indicated that widespread use of proguanil as a suppressive drug in a malarious area may result in the appearance of proguanil-resistant strains of *Plasmodium falciparum* and *P. vivax*. Tests with window-trap huts, supplementary to a house-spraying programme, confirmed that DDT at 200 mgm. per sq. ft. and BHC at 40 mgm. gamma isomer per sq. ft. are effective for nearly six months, but suggested that lower doses last only about two months against *Anopheles maculatus*. At Tambunan, North Borneo, encouraging results have been obtained from the experimental jungle clearance for the eradication of *A. balabacensis* and the malaria it carries. Work is being continued in West Africa to relate human age groups to the natural infections in *A. gambiæ*, *melas* and *funestus*. Preliminary results of an experimental malaria eradication scheme at Ilara, Southern Nigeria, are summarized in the report, and in field-trials on selected African children, the 2 : 4-diaminopyrimidine derivative, 'Daraprim', was comparable with 'Mepacrine' in its schizonticidal effect on the trophozoites of *P. falciparum*, but the effective dose per child was as low as 5 mgm.

* Continued from p. 114.

The West African Virus Research Institute, Lagos, has undertaken work on the use of the vaccine produced by the Pasteur Institute, Dakar, in outbreaks of yellow fever in the Gold Coast, and in Onitsha Province field-trials with aureomycin indicated no beneficial effect on the clinical course of yellow fever or on the level of viræmia. The East African Virus Research Institute, Entebbe, has been associated with the World Health Organization's scheme for delimiting the southernmost boundary of the yellow fever area in Africa and is examining human bloods from the Belgian Congo, Angola, Tanganyika, Northern Rhodesia and Nyasaland. Work by the Scrub-typhus Research Unit in Malaya has been consolidated, and investigations made in Malaya during 1951 by the Scrub-Typhus Research Unit of the United States Army Medical and Graduate Research School, with its headquarters at Kuala Lumpur, are summarized in the report. Specific antisera of great value in the accurate identification of blood meals and tsetse flies have been prepared by a 'cross-immunization' technique at the Lister Institute of Preventive Medicine, London, while the investigation of serum proteins continues at Makerere College, where a thorough investigation of the biochemistry of kwashiorkar as seen in children is in progress. Progress is reported in all established lines of research at the Tropical Physiology Laboratory, Oshodi, Nigeria, where a linear relation has been established between sweat-rate and corrected effective temperature and an extensive investigation has been made in the deep mine of the Ashanti Gold Fields Corporation at Obuasi, Gold Coast.

At the Field Research Station, Fajara, Gambia, investigations, assisted by a large contingent from the Medical Research Council's Human Nutrition Research Unit, into nutritional disorders and into infections, particularly with malarial parasites, which contribute to ill-health, have continued and work on food technology has been resumed. In Nigeria studies of the use of adrenocorticotropic hormone (ACTH) and cortisone in leprosy have been made.

During the year, grants totalling £373,553 towards new and existing schemes were made by the Committee for Colonial Agricultural, Animal Health and Forestry Research, the seventh annual report of which pays special tribute to the assistance given by the Commonwealth Institute of Entomology, the Institute of Biological Control, Ottawa, and the Mycological Institute. The East African Agriculture and Forestry Research Organization moved into its new headquarters at Muguga South, Kenya, early in the year. Its work on the relation between calcium and phosphate in the soil system is now being extended to the analyses of plant samples from fertilizer trials. Studies on groundnut virus diseases continued, substantial progress was made in studies of canker disease of cypresses in elucidating the resistance of different species to strains of the fungus and the relation between age of tree and susceptibility, and work has begun on the incidence of the bud disease of the pyrethrum plant caused by *Ramularia bellumensis*. The East African Veterinary Research Organization continued its work on animal trypanosomiasis, including the use of 'Antrycide', and on animal

helminthology and nutrition, and the mobile unit concluded its tuberculosis survey in the Southern Highlands Province of Tanganyika. In West Africa, regional research schemes into rice cultivation and the rust disease of maize caused by *Puccina polysora* have been started, while at the West African Cacao Research Institute a satisfactory method was devised of controlling capsid bugs on young cacao. The former Oil Palm Research Station of Nigeria has been converted into a semi-autonomous West African Institute for Oil Palm Research, covering the needs of all the British West African territories.

In cacao research in the West Indies, a study of the degree of pod-infection by witches' broom disease has indicated wide variations in the susceptibility of different clones to the disease. Research on the banana has shown that the most promising breeding programme is to raise primary tetraploids using the Gros Michel as the female parent, and that better male parents are required than those hitherto used in Trinidad and Jamaica. Arrangements have been made for research into leaf-scald disease of sugar-cane, a serious threat to the economy of British Guiana, and a small team of scientific workers is making an ecological land-use survey of British Honduras. Among work undertaken by Colonial Departments of Agriculture, Forestry and Veterinary Services mentioned in this report may be noted the investigations into the control of the root borer of sugar-cane, *Diaprepes abbreviatus*, in Barbados by the use of 'Agrocide' preparations and 'Aldrin', trials of insecticides in Fiji and the successful biological control there of *Cirphis unipuncta* in rice-fields, work on methods of rinderpest vaccine production in Kenya, on the sulphur content of 'gelam' soils in coast alluvium in Malaya, on soil conservation in Sierra Leone, on coffee in Tanganyika and on the damage to coconuts caused by the coreid bug, *Theraptus* sp., in Zanzibar.

The fifth annual report of the Colonial Insecticides, Fungicides and Herbicides Committee gives fuller details of some work which is referred to elsewhere in these reports. The study of insecticidal surface coatings at the Colonial Insecticide Research Unit, Porton, has reached the development and field-trial stage. Treatment of various parts of ships voyaging through the tropics has given very promising results against cockroaches and ants, and appears to give some freedom from flies and mosquitoes entering at ports. In certain formulations the coatings are of value in protecting marine woodwork from barnacles and in the control of book insects in old libraries. Other work at Porton, at Rothamsted and at the Imperial College Field Station, Silwood Park, on the way in which contact poisons are picked up by insects, and the influence of particle-size and the type of surface on the amount picked up, should contribute to important improvements in insecticide formulations and methods of application.

Aircraft studies in East Africa in the application of chemicals to vegetation continued on a reduced scale: final observations on the treatment of 15 square miles of tsetse bush with DDT spray show a reduction of two species of tsetse by more than 99 per cent and of a third by more than 95 per cent. Two-year studies on the behaviour of *Anopheles gambiæ* and *A. funestus* in huts treated with DDT, BHC and other insecticides do not support the view that DDT is ineffective against *A. gambiæ* because it repels them from the huts, but 'Dieldrin' is more effective as residual spray against mosquitoes than either DDT or BHC. Trials of three new sprays for the residual spraying of houses for mosquito control are being carried out under Colonial conditions. Preliminary experiments have been conducted in Africa by the Unit of Experimental Agronomy, Oxford, on the use of defoliants and arboricides in control of tsetse fly.

In its fifth annual report, the Colonial Economic Research Committee reports extra difficulty in finding suitable candidates for undertaking research, and although several appointments were made to the regional institutes, recruitment of senior economists for short-term research appointments remains difficult. The Colonial Research Council has recommended the use of £100,000 of the remaining Colonial Development and Welfare Research allocation for promoting economic research, and part of this allocation will be devoted to research conducted by institutions in the Colonies. Considerable progress is reported in the Nigerian National Income Survey, which is being conducted by the Department of Applied Economics in the University of Cambridge, and Dr. P. T. Bauer's study of the structure and organization of trade in West Africa is almost complete.

The report of the Tsetse Fly and Trypanosomiasis Committee for the year ended March 31, 1952, states that the programme of work of the East African Tsetse and Trypanosomiasis Research and Reclamation Organization for 1951–56 provides for the continuance of the basic research of the past five years and for extensions into the field of animal trypanosomiasis when the facilities of the Central Trypanosomiasis Research Institute are available. Meanwhile, the prophylactic and curative properties of 'Antrycide are being studied in co-operation with the East African Veterinary Research Organization. Full facilities at the West African Institute for Trypanosomiasis Research only became available during the year, but a tsetse breeding colony is being established in the laboratory. A new field-investigation on the epidemiology of human sleeping sickness was commenced in the Gambia, and a pilot experiment in Nigeria has shown that N'dama cattle show a remarkable tolerance to trypanosomiasis even when exposed to a severe challenge from *Glosina morsitans*. A zoologist has been appointed to collate information available on the mammalian fauna of Africa, and the Kenya Veterinary Department has further investigated delayed toxicity following the use of phenanthridinium compounds.

The annual report of the Colonial Fisheries Advisory Committee on Fisheries Research for 1951–52 reports a satisfactory recruiting position. There are now fifty-one fisheries officers, and at December 31, 1951, £1,532,500 had been allocated to thirty-four fishery research schemes, leaving a total balance in hand of £174,300, against which commitments for new schemes and the extension of existing schemes until March 31, 1951, amount to £120,000. At the Inter-Territorial Fisheries Research Station at Jinja on Lake Victoria, a comprehensive programme of research has been started with the object of acquiring an understanding of the principal factors which determine the density of fish populations in the various lakes of Central Africa. The importance of diatoms in the economy of the Lake has been demonstrated, and considerable light thrown on the rate of growth and sexual periodicity of fish living in tropical waters. Results obtained by the Inter-Territorial Marine Fisheries Research Station at

Zanzibar indicate that pelagic fishes haunt the edges of the shallow marginal waters. The large research trawler of the Western African Fisheries Research Institute has made her first six trips, and a hundred species of fish were identified; the Institute has also started a study of the ecology and biochemistry of mangrove swamp.

The report of the Director of the Anti-locust Research Centre on locust research and control for 1951–52 refers to the resumption of investigations on the conditions affecting the incidence of flight and the speed and direction of swarm displacements following the reappearance of desert locust swarms in East Africa at the end of 1950. The type of flight performed by locusts is of importance in determining the rate of displacement, and sustained flight appears to require high humidities. Research activities of the Desert Locust Survey included the exploration of less known desert locust areas in Arabia, and studies on locust biometrics, hopper behaviour and ecology. Intensive work has been carried out on the ecology and population dynamics of the Moroccan locust in Cyprus, and the Desert Locust Control Organization based on Nairobi was strengthened during the year. Growing international co-operation is an encouraging feature of the present control campaign. A memoir on the desert locust in the Indo–Pakistani–Persian area is being edited for the press, and completes the series of memoirs dealing with generalized seasonal breeding and migration of swarms throughout the desert locust invasion area.

FISHERIES RESEARCH IN BRITISH COLONIES

IMMEDIATELY after the Second World War an extensive programme was set in motion under the Colonial Development and Welfare Act of 1945 to set up centres for fishery research in the British Colonies. It was realized that in fish there was a source of much-needed proteins which has scarcely been tapped. Of the research institutes to be developed the first to become established was that of the East African Fisheries Research Organization* at Jinja in Uganda under the directorship of Mr. R. S. A. Beauchamp. The publication of the Organization's annual report for 1951 affords evidence that the work of the Jinja laboratory is now beginning to bear fruit.

Research has been centred on Lake Victoria, and regular observations are showing how complicated are the conditions of a large tropical lake and how different they are from the classical picture supplied by the study of temperate lakes. The work is primarily aimed at finding out the economic possibilities of fishing, and to this end a study is being made of the fish populations, their food and ecology. With opportunities for regular observations over a number of years, it should be possible to answer outstanding questions on the growth and breeding of fish under tropical conditions. For this purpose a background knowledge of the conditions under which the fish live is essential, and investigations on the hydrology and algology are being made. Among results obtained to date, the possibilities of a new fishery for Mormyrids has been demonstrated; information has been gained about a number of fish which will help towards assessment of the effects of fishing on their populations*; the ability of fish to digest different types of algæ has been shown, as well as the notable importance of insect larvæ as food. Among other practical aims is the study of molluscs and the distribution of trematode parasites, especially *Schistosoma*.

But what is at once obvious from the report is the enormous and varied field for study, and the wealth of problems waiting to be solved in the teeming high-speed realm of tropical aquatic life. Many of these are fundamental questions which will need to be answered before the life-stories of the fish can be properly understood. In view of this it is most gratifying to note that visiting research workers from British and overseas universities are already finding their way to Jinja to work on their various private lines of research. In this way the work of the fisheries laboratory is advanced, and visitors and staff benefit enormously by mutual discussion and friendship. It is to be hoped that, when other laboratories are ready, more visiting research workers will seek the facilities they afford. The laboratory of the West African Research Organization at Freetown is reaching that stage.

F. S. RUSSELL

* East Africa High Commission: East African Fisheries Research Organization. Annual Report. 1951. Pp. ii+49. (Nairobi: Government Printer, 1952.)

* Colonial Office. Fishery Publications, Vol. 1, No. 2: Report on the Tilapia and other Fish and Fisheries of Lake Nyasa, 1945–47. By Rosemary H. Lowe. Pp. x+126+7 plates. (London: H.M. Stationery Office, 1952.) 40s. net.

HUMBER LABORATORY FOR FISH RESEARCH

A NEW laboratory for fish research, to be known as the Humber Laboratory, was opened in Kingston-on-Hull on December 5 by Sir Ben Lockspeiser, with Dr. Franklin Kidd, director of food investigation of the Department of Scientific and Industrial Research, in the chair. Some hundred representatives of all sections of the fish industry were present, as well as representatives of various official bodies. The new venture was heartily welcomed on behalf of the industry by Admiral Sir Robert Burnett, chairman of the White Fish Authority, and by Mr. J. Croft Baker, chairman of the British Trawlers' Federation.

The new laboratory is a sub-station of the Torry Research Station, Aberdeen, which since its inception in 1929 by the Department of Scientific and Industrial Research has been the base for practically all the research undertaken in Britain into the problems of the preservation of fish as food. Aberdeen has proved a most suitable centre for research owing to the close proximity of fishing grounds for supplying experimental material and the presence of the University and other local research institutes, particularly the Marine Laboratory of the Scottish Home Department. However, during the past twenty-five years the area habitually fished by British trawlers has extended to the regions of Bear Island and Spitsbergen, the Barents Sea and Greenland, and on occasion Newfoundland and the Davis Strait. Nearly three-fifths of the white fish brought to Britain during 1951 came from these distant waters. This distant-water fishing is concentrated on the Humber ports of Hull and Grimsby, which together accounted for more than three-quarters of the distant-water catch and just over three-fifths of Britain's total white-fish landings of more than eight hundred thousand tons.

This was six times the quantity landed in Aberdeen, and was worth five times as much, namely, £22 million.

The distance of these prolific fisheries makes it more difficult to keep the catch in good condition on the voyage home, a journey that can take up to a week, after which inland distribution has still to be undertaken. In comparison, voyages to the nearer waters of the North Sea and Faroe Islands are much shorter and the catches much smaller. Since 1947 the Torry Research Station has been paying particular attention to the problems of improving the preservation of the distant-water catch, most of which consists of cod and haddock, and the establishment of the new Laboratory will provide a permanent base on the Humber which will make further work in this field much easier.

In opening the Laboratory, Sir Ben Lockspeiser pointed out that, of the three main sources of animal protein, meat and dairy produce have to be largely imported, much of it from dollar areas, while fish is mostly obtained by our own efforts. In consequence, it is rather surprising that although the British are consuming substantially less meat to-day than before the Second World War, they are, in fact, consuming per head less fish. Sir Ben gave as an example the kipper, a typically British product, of which, he said, the consumption is now only about half of what it was in 1947 and 1948. People will not eat fish willingly unless it reaches them in good condition, fresh or processed, and this raises questions of refrigeration, storage, smoking and canning. It would be wise to assume that Britain will have to rely increasingly on fish in the foreseeable future, and it becomes, therefore, more than ever important that the resources of fish, which are obtained with such cost in capital and labour and all too often in human life, should be husbanded. The Department of Scientific and Industrial Research, continued Sir Ben, is opening the new Laboratory on the Humber in the heart of the white-fish industry in order to help to come to grips with the practical problems of distant-water fishing. Industrial science is in the nature of a joint enterprise between industry and science. Although every now and then science takes a leap forward, creating a revolution in thought and practice, which it is vital for an industrial nation to recognize and take advantage of, more frequently advance is step by step, often in very small steps, every one of which has to be tested in practice. The Department of Scientific and Industrial Research attaches great importance to working in partnership with all sections of the industries it serves.

After the opening, visitors saw an exhibition of some of the results of recent work of Torry Research Station. The bacteriological problems of keeping fish fresh were illustrated, and an account was given of the methods used and results obtained in an extensive survey of the conditions of handling fish aboard distant-water trawlers, showing the temperature distribution in the fish holds and the loss of weight of fish during transport. Even with the most careful handling aboard ship, however, not all fish can be landed from the distant waters in a really fresh condition by the normal process of gutting, washing and icing. Another exhibit described work on the problems of preserving fish by freezing at sea, with samples of fish frozen in a new type of contact freezer now being developed for the purpose. The deleterious effects of the cold storage of fish at temperatures of − 10° to − 15° C. for a few months was demonstrated by contrast with the perfect condition of similar fish stowed at − 30° C. for up to twelve months.

Various physical, chemical and engineering problems involved in the preservation of fish by smoking and drying were illustrated. Some demonstrations were given of the recently developed humidity-sensitive element which utilizes some electrical properties of anodized aluminium (see p. 177 of this issue). Several by-products of the fishing industry, and new methods of recovery, were described as well as current research on fish proteins, and work on fish skin being carried out at the Zoology Department of the University College of Hull for the Department of Scientific and Industrial Research.

The buildings for the new Humber Laboratory have been erected by the Ministry of Works and comprise four laboratories, a workshop, offices, a library, and space for handling, freezing and smoking fish on a semi-commercial scale. Altogether, this new establishment will function as an integral part of the Torry Research Station, providing facilities for workers from that Station as well as for its own as yet small staff, and continuing work on various fronts—for example, certain aspects of fish chilling, freezing, smoking and drying. It is hoped that, in addition to *ad hoc* problems, the programme will include basic biochemical and physicochemical studies in fish preservation.

PROBLEM OF FUTURE WORLD FOOD SUPPLY

THE Nutrition Panel of the Food Group of the Society of Chemical Industry has arranged a series of meetings devoted to the subject "Food and the Future". The opening meeting of the series, under the title of "The Problem of Future World Food Supply", was held on December 10, with Dr. J. I. M. Jones in the chair.

Mr. F. Le Gros Clark spoke on the "Yardstick of Population" and posed the question, "Will there soon be too many of us ?", pointing to an eventual finite limit to the population that could be supported by the world. Famines have always been local and temporary, never of world dimensions, but the real cause for alarm is that no one can foresee in what precise corner of the world hunger may occur. Optimists, he said, believe that men, even after a long period of suffering, will learn to control their fecundity, while pessimists foresee only disaster.

Mr. Le Gros Clark traced the growth in population over the centuries, suggesting an eventual total of 8,000–12,000 million before stability is reached. The problem of their food supply requires not mainly a technological transformation but a revolution in the habits of men and methods of farming—an agrarian revolution on a world-wide scale. The initiation of this revolution, he said, should have started fifty years ago, before the pressure of population had become so great. Nowadays, we cannot be excused because of ignorance, as perhaps could our grandfathers, who had less factual knowledge.

Most nations to-day, protested Mr. Le Gros Clark, are not giving the agricultural scientist and food chemist half the chance they should have of meeting the challenge. This is a matter for governments and people who move governments. The task before us,

he concluded, is that of agrarian reform, carried out in such a way as to convert a largely illiterate peasantry into alert, modern farmers who can manage the breeding not merely of their farm animals but also of themselves.

Dr. E. W. Russell dealt with the "Factors Limiting Food Production". In Great Britain differences in output between farms depend upon soil, varying use of fertilizers and varying degrees of farming skill. Large areas of hill lands are producing only a fraction of the food per acre produced by the lowland areas, principally due to climate, lack of plant nutrients in the soil and relatively poor farming-skill in these areas. Skilled and energetic farmers must be attracted back to the hills, and this requires the provision of reasonable living amenities such as housing, transport and recreation in districts very deficient in these.

In the world as a whole, food production is limited by three groups of factors. First there are the inherent factors of the site: lack of soil, water, nutrients or a short growing-season. Then there are factors that harm the growing crop such as diseases and pests. Finally, there are human factors, including lack of skill, low activity due to disease, and social, religious and political brakes on production.

Dr. Russell gave examples of yields of rice in different countries, and showed that the extremely low yield in India, less than a quarter of that in Italy, had been doubled in one area by using better varieties, better water management and simple manuring. Crop production is limited by cold, but new strains ripening in a short season could be grown in cold districts before the frosts came. At the present time, the principal factors limiting wheat production in the Canadian prairies are believed to be lack of men and lack of markets rather than lack of suitable land. Dr. Russell also dealt with irrigation, fertilization of the soil and soil erosion.

A. E. Bender

ROYAL OBSERVATORY, CAPE OF GOOD HOPE

REPORT FOR 1951

THE report of the Royal Observatory, Cape of Good Hope, chronicling the activities of the Observatory during 1951, has recently been published*. It is satisfactory to know that the modernization of the reversible transit circle, which had been originally built in 1900, was completed in 1951 and it was ready for use in November. An important change was the replacement of the twelve declination circle microscopes by twelve cameras, six on either pier, which, on pressing a button, photograph the position of the declination circle and automatically wind on ready for the next exposure. Various troubles with instruments have been eliminated; one of these arose from the harshness in the sun-and-planet differential through which the guiding motion is applied to the impersonal micrometer; and after trying alternative methods for securing a suitable differential motion, it was decided to retain, with a few minor changes, the form of drive introduced in 1911 by Mr. Hough. The Hipp chronograph, which frequently gave trouble, has been replaced by a new chronograph built at the Observatory and driven by a synchronous electric motor.

The Victoria telescope, now more than fifty years old, was used on 177 nights, 121 for the parallax and proper motion programme, 25 for photoelectric photometry, 19 for Fabry photometry and 12 for obtaining direct photographs in connexion with various photometric programmes. The instrument was also used for observing occultations both photoelectrically and visually. Arrangements have been made for an examination of the declination axis of the telescope, around which the motion has become increasingly stiff during the past few years. The astrographic refractor was used on 146 nights and the 7-in. telescope on 120 nights in connexion with the "Bright Star Programme"; as this is now finished, it is proposed to use the latter telescope only for visual observations, such as occultations and the micrometric measurement of double stars. The 6-in. telescope has been used to observe long-period variables and also for occultation work as well as for visitors. The tower telescope has been used for observing occultations and variable stars, and the photoheliograph is used daily to take two photographs of the sun. There have been developments in the photoelectric equipment during the year, two D.C. amplifiers and two power-packs having been designed and constructed, while great improvements have been made in the occultation apparatus which was described in the 1950 report.

In April 1951 an agreement was signed between the Radcliffe trustees and the Admiralty by which one-third of the time with the 74-in. Radcliffe reflector at Pretoria is made available to observers from the Cape. The scheme is to use the Radcliffe telescope for long routine programmes for which the organization of the Cape Observatory is particularly suitable and which are not likely to be undertaken by individual observers of the Radcliffe Observatory, and two routine programmes have been already started: one of these is for determining the radial velocities of the southern stars; the other is a photographic *Durchmusterung* of the southern Kapteyn Selected Areas. Among the miscellaneous items of the report are included observations of the spectra of a selected list of planetary nebulæ, photographs of extragalactic nebulæ, spectrograms of a number of specially interesting stars, and certain experimental work. The last includes some experiments made in collaboration with the Electronic Division of the National Physical Laboratory as to the capabilities of the new E.M.I. tube for astronomical photometry. Full-scale deflexions were obtained with the 74-in. telescope on stars of magnitude 15 without the use of an amplifier.

So many other matters are dealt with that it is impossible to mention them all, but one or two additional points are worth noticing. Mr. A. N. Cox, of the University of Indiana, visited the Cape Observatory in September 1950 and installed on the Victoria telescope the photoelectric photometer that had been previously used in the United States and at the Radcliffe Observatory. After his return to the Kirkwood Observatory, he compared the stars that he measured in the regions $C2$ and $C12$ directly with the North Polar Standards, and the remarkable thing is that the results were not in agreement with those found at Cambridge. It is suggested that the non-agreement may be merely one more indication of the grossly unsatisfactory nature of the present standard

*Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the year 1951. Pp. 20. (Cape of Good Hope: Royal Observatory, 1952.)

magnitudes in the northern hemisphere. Short descriptions are given of the time service, meteorological observations and publication of results. Continuous records were obtained on self-registering instruments of barometric pressure, temperature, humidity, wind direction and wind velocity; observations were made daily at 8 hr. S.A.S.T. The report ends with a list of the personnel and of distinguished visitors to the Observatory during 1951. Regular visiting days, which were started in August 1950, were continued during 1951.

HÆMOGLOBIN AND BILIVERDIN IN PARASITIC CIRRIPEDE CRUSTACEA

By Prof. H. MUNRO FOX, F.R.S.
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In 1946, Pérez and Bloch-Raphaël[1] announced the presence of hæmoglobin in the rhizocephalan cirripede *Septosaccus cuenoti* Duboscq, parasitic on a hermit crab at Roscoff. This increased from three to four the number of orders in the Crustacea Entomostraca known to possess hæmoglobin[2]; it is present in the Branchiopoda, Ostracoda, Copepoda and Cirripedia, being unknown only in the small fifth order, the Branchiura (containing *Argulus*). It is curious that, in Copepoda and Cirripedia, hæmoglobin occurs only in parasites. In contrast to the Entomostraca, no member of the Malacostraca possesses hæmoglobin in the blood or elsewhere in the body, while two malacostracan orders, the Decapoda and Stomatopoda, have hæmocyanin in their blood.

The roots of the cirripede *Peltogaster*, parasitic on hermit crabs, are green, unlike the yellow roots of *Sacculina*. Lederer[3] discovered that the green pigment of the roots of *Peltogaster paguri* (Rathke) is biliverdin; he based his conclusion on solubilities and the Gmelin reaction. Pérez and Bloch-Raphaël[1], using the Gmelin reaction, detected this pigment also in the roots of *Septosaccus*. It was natural that the latter authors should consider the biliverdin to be a degradation product of the parasite's hæmoglobin, as it is in the Vertebrata. Their paper was followed by two more on hæmoglobin and biliverdin in *Septosaccus*[4,5]. I have now had the opportunity, at the Zoological Stations of Naples and Villefranche, of studying these pigments in three other members of the Rhizocephala.

At Naples, *Peltogaster curvatus* Kossmann parasitizes two species of the hermit crab genus *Eupagurus*; it is found, namely, on *E. prideauxi* (Leach) and *E. excavatus* (Herbst)[6]. All individuals of *E. prideauxi* studied by me, but none of *E. excavatus*, bore the commensal anemone *Adamsia palliata* (Bohadsch). *Eupagurus prideauxi* is the commoner species of hermit crab, but only about 1 per cent of individuals are parasitized by *Peltogaster*, whereas about a quarter of the individuals of *E. excavatus* bear a parasite. The external part of the parasite is orange in colour, with a reddish tinge which is more or less pronounced in different individuals; the orange pigment is soluble in acetone and is probably a carotenoid. The parasite possesses hæmoglobin in solution in its blood, which is most conveniently obtained from the external part of the parasite near the stalk. Drops of blood of a standard depth, held between coverslip and glass plate of a compressorium, were examined with a microspectroscope. In the blood of some individuals the oxyhæmoglobin absorption bands were strong and in others weak. The accompanying table gives the numbers of individual parasites which showed oxyhæmoglobin bands of five arbitrary intensities.

Host	Numbers of parasites with oxyhæmoglobin bands of various strengths				
	Very weak	Weak	Medium	Strong	Very strong
E. prideauxi	8	3	4	2	1
E. excavatus	—	1	—	9	10

The data show not only a considerable variation in the hæmoglobin content of individual parasites, but also a difference in amount of hæmoglobin depending upon the species of host. Normally a host carries a single parasite, but four individuals of *Eupagurus prideauxi* were found each of which bore two *Peltogaster curvatus* and usually the two parasites had quite different hæmoglobin contents. (Pérez and Bloch-Raphaël[1] found no hæmoglobin in *Peltogaster*, but they do not give species, host or number examined.)

The roots of *Peltogaster curvatus* within the host have an intense green colour, easily seen through the abdominal wall of the host. The green is due to biliverdin; I was able to show this, not only by the Gmelin colours, but also in three other ways. The roots were dried and then dissolved in methanol. (1) When nitric acid was added to the green methanol solution, the resulting purple had a strong absorption band with its axis at 493 mμ and a weaker one at 604 mμ. (2) When zinc acetate and iodine were added to the methanol solution an absorption band appeared at 636 mμ. Pure biliverdin treated in the same two ways gave the same bands. The wave-lengths were determined with the Hartridge reversion spectroscope. (3) Additional evidence of biliverdin was furnished by the solution in methanol with zinc acetate and iodine showing a pink fluorescence in ultra-violet light, which changed to a green fluorescence on the addition of more iodine.

In one individual of *Peltogaster curvatus*, nearly fully developed nauplii were present in the mantle cavity, most of them still within their embryonic membrane. They were light yellowish-pink in colour and contained no detectable hæmoglobin, although the parent had the pigment in its blood. Bloch-Raphaël[4] found biliverdin in the ripe eggs of *Septosaccus* and "bile pigments" in the nauplii. She remarks that these degradation products of hæmoglobin which are in the larva will be able "in the host" to take part in the synthesis of hæmoglobin. This statement is unjustified, since bile pigments are not known to be a step in hæmoglobin synthesis.

The second rhizocephalan species examined was *Parthenopea subterranea* Kossmann, parasitic on the anomuran *Callianassa laticauda* Otto. This is the only existing species in the genus *Parthenopea*, and it is known only from the Gulf of Naples, where 1–2 per cent of individuals of the host species are parasitized. The external parasite has a pinkish-orange colour, this pigment again being soluble in acetone. Eight parasites were examined spectroscopically but no oxyhæmoglobin bands were detectable, even in the pinkest specimens. The blood contains a variable quantity of a violet-pink pigment which has no

absorption bands. With pyridine the blood gives only a weak α-absorption band of hæmochromogen: thus little hæm is present.

The part of *Parthenopea* internal to the host consists of ramifying green roots. Again the green colour is due to biliverdin, giving Gmelin's test. The colour is not so striking as in *Peltogaster*, but this is probably because the roots are more slender and are not bunched together. Here we have an animal with a bile pigment but no hæmoglobin. Biliverdin is already known from a crustacean lacking hæmoglobin, namely, an American 'crawfish'[7], in which it has been found in the liver. This fact, together with the presence of biliverdin without hæmoglobin in *Parthenopea*, suggests that in *Septosaccus* and *Peltogaster* the biliverdin is not necessarily derived from the hæmoglobin. As stated above, *Parthenopea* has a hæm compound, although no hæmoglobin, in its blood, and the biliverdin in the roots may perhaps be a breakdown product of this hæm. Another example of animals that have a bile pigment but no hæmoglobin is provided by insects with green integument or blood, the colour of which is due to a blue bile pigment together with a yellow carotenoid[8]; the insects possess, of course, a hæm compound in the form of cytochrome. The mollusc *Aplysia* has urobilin in the liver and also in the externally secreted pigment aplysiopurpurin[9] without having hæmoglobin in the blood, but there is abundant hæmoglobin in the buccal muscles.

It has been known for a long time that the liver of some decapod Crustacea contains a hæmochromogen[10]. With a reducing agent its α-absorption band becomes visible, and a more intense band can be obtained when pyridine is added, through the conversion of this hæmochromogen and of other hæm compounds to pyridine hæmochromogen. In *Callianassa laticauda* it was therefore not surprising to find a hæmochromogen present in the liver. An examination was made of forty-four individuals, half of them parasitized, and it was found that more pyridine hæmochromogen is obtainable from the liver tissue of unparasitized than of parasitized animals. This suggests at first that the hæm in the part of the parasite external to the host is derived from hæm in the host. But this tentative conclusion is not well founded, for the lobes of the parasitized host's liver are visibly atrophied. Their deficit in hæm may therefore well be due to the disturbance in the normal development and functioning of the liver, rather than to a draining away of its hæm into the parasite.

Peltogaster and *Septosaccus*, which are parasitic on hermit crabs, contain hæmoglobin, while *Parthenopea*, parasitizing an anomuran, and *Sacculina*, on crabs, lack the pigment. In the first two genera the external parasite is within the hermit-crab's shell, or enveloped by the anemone *Adamsia*, in a situation where the oxygen content of the water may not always be high, whereas in the other two genera the external parasite is freely bathed by the sea water. This suggested that the hæmoglobin of *Peltogaster* and *Septosaccus* might be synthesized in response to oxygen deficiency as in *Daphnia*[11]. But, for the following reason, this cannot be so. The anomuran *Galathea squamifera* Leach at Villefranche is parasitized by the rhizocephalan *Galathescus squamifera* Pérez. I was able to examine four parasites, on separate hosts. They were pinkish-orange in colour, had hæmoglobin in the blood and possessed green roots. In two specimens the hæmoglobin was strong, in two it was weak; there is thus the same variation in quantity as in *Peltogaster curvatus*. In *Galathescus* the external part of the parasite is freely bathed by sea water, and so the possession of hæmoglobin cannot be ascribed to lack of oxygen. Thus neither causal nor functional reasons are as yet known for the presence or absence of hæmoglobin in Rhizocephala. [Sept. 24.

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GENETIC INTERACTION BETWEEN INFLUENZA VIRUSES

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IT is now well established that when bacteria are doubly infected with appropriately chosen strains of bacterial virus, 'recombinant' virus types may be obtained among the progeny liberated on lysis[1,2]. No final interpretation of the phenomenon has yet proved acceptable, Luria's hypothesis[3] of independent gene multiplication followed by reaggregation of the genetic apparatus of the virus from the resulting gene pool having been withdrawn as inadequate by the author on the basis of Dulbecco's results[4].

Technical difficulties make it impossible to handle animal viruses on the scale, or with the quantitative precision, possible with bacterial viruses. The use of growth in the allantoic cavity of the chick embryo and hæmagglutination methods, however, provides some approach to such precision in work with well-adapted influenza virus strains. There are now many convenient ways by which influenza virus strains can be characterized, and it is not difficult to find, for example, two influenza *A* strains which can be differentiated from one another by six or more conveniently demonstrable differences. Evidence for genetic interaction between two such virus types has been sought for some years in this laboratory, and in 1949 results were obtained indicating that by double infection of the mouse brain with a neurotropic influenza virus, *NWS*, and a non-neurotropic virus of different serological type (*MEL*, *SW* or *Oc.I.*) strains could be obtained of the second serological type but carrying the neurotropism and some of the other characters of *NWS* (Burnet and Lind[5]). This phenomenon is readily reproducible, but the interpretation that it represents an example of genetic recombination has not yet found acceptance among other workers.

In the hope of obtaining a more readily analysed example of such interaction between two viruses, attention has now been turned to double infection in the chick embryo. For the first series of experiments, the two strains *NWS* and *MEL* which had been used for most of the work previously reported were chosen. In a sense, the neurotropism of *NWS*

for mice finds expression in the chick embryo by its capacity after inoculation on to the chorioallantois to invade the embryo and produce hæmorrhagic lesions particularly in the brain and muscles. Virus *MEL* has no such action. If mixtures of the two viruses with *MEL* in 100- to 1,000-fold excess are placed on the chorioallantois, hæmorrhagic brain lesions develop after three to four days incubation. Most such lesions contain both *NWS* and what we have called *NM* virus. The latter, which is serologically *MEL* and capable of producing hæmorrhagic lesions in the embryo, may be present in excess, so that it can be isolated by simple titration in the allantoic cavity or it may require the use of an anti-*WS* serum to suppress an excess of *NWS* before this can be done. When isolated and re-isolated by limit titration in the allantoic cavity, the *NM* strains derived solely from chick embryo manipulations are identical in all respects with those formerly obtained in mouse brain experiments. It is of particular interest that a considerable proportion are capable of producing fatal encephalitis on intracerebral inoculation in mice. Of nine tested, four were consistently lethal, one strain produced a proportion only of deaths and four gave rise to no recognizable symptoms. This is very much the same distribution of pathogenicity which was found among the *NM* strains (defined on certain *in vitro* characters) obtained in mouse experiments[6].

On the hypothesis that *NM* virus was liberated from cells doubly infected with *NWS* and *MEL*, it was decided to use a method developed in this laboratory by Cairns[7] for obtaining 'first-cycle' virus from the allantoic cavity. Briefly, a large dose of a mixture of *MEL* and *NWS* virus, adjusted to approximately equal concentration of the two viruses on the basis of their hæmagglutinating titres, was inoculated into each of four to six 11-day embryos. After one hour's incubation, 2,000 units of semi-purified receptor-destroying enzyme of *Vibrio choleræ* was introduced into the cavity to liberate any adsorbed but non-infecting virus and to prevent loss by adsorption of the liberated first-cycle virus. The allantoic sacs were repeatedly washed out with warm saline and then left until half-hourly tests showed a rising hæmagglutinin titre. The fluids were then harvested and a pool of all satisfactory fluids tested for its content of virus. By appropriate titrations with and without antisera against the two viruses, one such pooled first-cycle fluid was found to contain *MEL* $10^{6.5}$ and *NWS* 10^{8} infective units. An artificial mixture of the same composition was prepared and the two tested in parallel by titration on the chorioallantois in the presence of anti-*NWS* serum. Three consistent experiments showed death of embryos with hæmorrhagic lesions from which *NM* virus was isolated, when the first-cycle fluid was used. The artificial mixture gave in two experiments only one out of twelve and one out of eleven embryos with lesions, in each case due to *NWS*. This was taken as evidence that the production of *NM* virus was possible in a single cycle of infection. It also seemed to eliminate any possibility that the *NM* strains arise by simple mutation from *MEL* or by some direct effect of the tissue environment.

The next step was to replace *NWS* by another *WS* variant, namely, *WSE*, which has no neurotropic activity in the mouse but is equally invasive and lethal for the chick embryo. It differs, too, in growing much more freely in the allantoic cavity than *NWS*, reaching the same level of hæmagglutinin as *MEL*. The choice of this pair of viruses was very fortunate, for in both the two extensive experiments so far completed the first-cycle fluid has been shown to contain in more or less equal amount four types of virus, namely, the two original forms *MEL* and *WSE* and two new types *M*+ and *WS*−, each of which combines some of the characters of both original forms. There are six well-defined characters which can be used to differentiate *MEL* and *WSE* viruses, and it is convenient to use these to designate *MEL* as *ABCDEF* and *WSE* as *abcdef*, each letter corresponding to one of the differentiating characters as follows :

Aa. Serological type *WS* or *MEL* as shown by hæmagglutinin inhibition tests with appropriate immune sera.

Bb. Heat stability : *MEL* hæmagglutinin resists 30 min. heating at 62°, whereas *WSE* hæmagglutinin is destroyed.

Cc. Conversion to 'indicator state' by simple heating at 56° for 30 min. When tested with ovomucin or meconium inhibitor, heated *WSE* hæmagglutinin is strongly inhibited ; heated *MEL* virus is unaffected except by very high concentrations.

Dd. Reactivity of heated virus with sheep salivary gland inhibitor[8] *WSE* is strongly inhibited ; no treatment of *MEL* has ever given a hæmagglutinin inhibited by this substance.

Ee. Production of hæmorrhagic lesions in the chick embryo after inoculation on the chorioallantois : this is characteristic of *WSE* but never shown by *MEL*.

Ff. Pathogenicity for mice by intranasal inoculation ; with a dose equivalent to one agglutinating unit, *WSE* kills all mice usually four or five days after inoculation ; *MEL* produces non-fatal lesions, grading 1–2 on the conventional scale.

The four types obtained then are represented :

ABCDEF	*ABcDeF*	*abCdEf*	*abcdef*
MEL (22)	*M* + (6)	*WS* − (9)	*WSE* (4)

The numbers in parentheses give the number of strains of each type isolated from thirty-seven virus-containing fluids obtained from embryos inoculated with dilutions of first-cycle fluid 85678 at or very near the limit of infectivity. From four fluids two types were isolated, accounting for the forty-one isolations shown. The only deviation from the four patterns shown above was that some *M*+ strains showed lower invasiveness for the embryo (*C*) than others, and in some tests two of the subinoculations from these have shown no lesions in the four embryos used, so they would be represented *ABcDEF*.

It will be seen that two characters only, *Cc* and *Ee*, appear to be transferable. It is particularly interesting that, in our experiments at least, one 'virulence' character, namely, the capacity to produce hæmorrhagic lesions in the chick embryo, is transferable, whereas another, pathogenicity for the mouse lung, is not. Similarly, one 'indicator' character, reactivity with ovomucin or meconium inhibitors, is transferable whereas behaviour toward sheep salivary mucoid is not.

These results at once exclude the possibility of simple mutation being responsible for the appearance of the new types. Some form of genetic interaction is clearly taking place, but there is no indication of a random reassortment of characters. Only four types have been observed, and the relationship between the new types *M*+ and *WS*− is a reciprocal one. It would be premature to speculate about the nature of the genetic interaction involved. The method used,

however, may be one of general application and seems likely to provide an important approach to the interpretation of differences between virus strains.

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PHYSICAL PROPERTIES OF PAPER PULPS

Elastic Properties of Wet Mats of Papermaking Fibres

IN the manufacture of paper, the initial formation of the fibre web on the wire of the paper-machine takes place in the presence of a large excess of water, the removal of which constitutes an important problem in paper technology. Bulk removal, for example, by draining, suction and pressing, is employed before resorting to the more expensive method of drying by evaporation, but the physics of the former process has not been extensively studied. Most of the water is present as liquid water within the inter-fibre capillaries, and is sometimes, though incorrectly, called 'free water' to distinguish it from water molecularly adsorbed.

The hydrostatic tensions associated with different regains have been studied on textiles by Preston and co-workers[1]. In their technique, similar to a method used by Haines[2] and Schofield[3] for soils, bundles of immersion-wet fibres are placed on a fine sintered-glass plate, to the underside of which a hydrostatic tension is applied barometrically. This tension is transmitted by the continuous water channels to the water in the fibre bundle.

Using suspensions of papermaking fibres, small cylinders (1 cm. in diam. and 1·5 cm. high) were formed by drainage in a manner resembling the formation of the wet paper web on the machine wire. At moisture contents (gm. water per 100 gm. dry fibre) up to approximately 1,000 per cent, these cylinders will retain their structure for experimental purposes, although they are soft and easily deformed under small stresses. As well as changes in their moisture content, it has been found possible to measure changes in their dimensions with changes in tension. Figs. 1 and 2 show results of such measurements for a sample of an unbeaten commercial kraft pulp. The sensitivity of the apparatus allows volume changes to be measured to an accuracy exceeding 0·5 per cent and tensions to 0·01 cm. mercury. The smallest measurable tension is equivalent to a controlled relative humidity of 99·99999 per cent. In the present experiments, liquid tensions up to 20 cm. mercury have been used, covering a range in relative humidity from saturation to 99·98 per cent.

At low tensions, when no air is present in the matrix, it may be assumed that an approximately uniform hydrostatic stress acts throughout. The volume of water removed per c.c. of cylinder represents a volumetric strain, so that a bulk modulus may be calculated (Fig. 3). Since the water is completely free to move, the modulus, k (1 bar = 10^6 dynes/cm.^{2}), will be that of the fibre matrix only. This is the modulus which, on the paper machine, determines the resistance of the wet paper web to further loss of water during drainage and suction. Compared to a material such as wood ($k \approx 400$ bars) where the fibres are everywhere in contact, the modulus is very low. As the moisture content falls the bulk modulus rises, due doubtless to the tighter packing of the fibres. By applying small directional stresses to the cylinder, it is hoped to investigate other elastic and plastic properties of the fibre system.

At higher tensions the entry of air into the system (at the point A) renders uncertain the significance of the measured bulk modulus. This occurs when the tension is sufficient to empty the largest capillary present and is followed by a more rapid fall in the moisture content. Following entry of air, there is frequently a marked increase in slope in the tension-strain curve (Fig. 2). In some cases, due to elastic rebound of the fibres, there is even a slight increase in dimensions despite increasing applied tension. Thereafter, progressively smaller capillaries empty and the desorption isotherm (Fig. 1) gradually becomes much steeper. Large increases in tension here produce little drying effect. This region corresponds to the condition under which air is drawn continuously through the wet paper web at the suction boxes.

It will be seen (Fig. 1) that there is considerable hysteresis between the sorption and desorption curves. This has been observed invariably, even when no air enters the system. On sorption to very high moisture contents, where further swelling of the cylinder is opposed by its own weight, it has been found practicable to surround it with a non-miscible liquid of appropriate density. By thus counteracting the gravitational forces, repeated cycles of sorption and desorption may be followed to very small tensions, at which the volume may increase to several times its former value. It is hoped to make these matters the subject of further research.

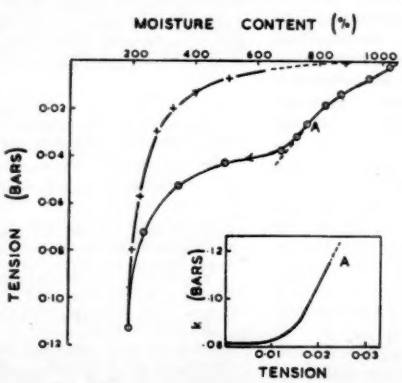

Fig. 1 Fig. 3

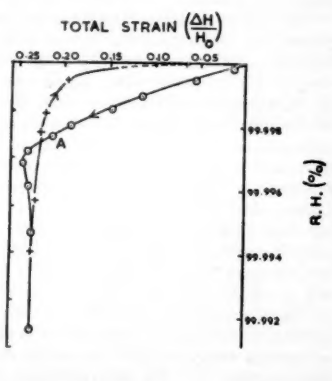

Fig. 2

One of us (G. N. C.) holds a research studentship from the Commonwealth Scientific and Industrial Research Organization of Australia.

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'Freeness' of Paper Pulps and the Forces of Capillary Water Retention

In the manufacture of paper, the cellulosic raw material is first dispersed into separate fibres by chemical or mechanical methods and is then subjected to a mechanical process called beating, which alters the properties of the fibres and has a profound influence on the quality of the finished paper[1]. Standard methods which have been developed to give an objective measure of the degree of beating (for example, the Canadian freeness test[2]) all depend on the rate of drainage of water from the fibre suspension. A light beating gives a 'free' pulp, which drains quickly, whereas a heavy beating gives a 'wet' pulp, which drains slowly.

Experiments have been made in the past to see whether a wet pulp shows greater hygroscopicity than a free pulp in the usual (vapour pressure–moisture content) isotherm between zero and near saturation humidity. The results show either no difference[3] or only a small increase with beating[4]. This suggests that beating is influencing only water held by capillaries at humidities which are too close to saturation to be controlled by conventional methods. Experiments have also been made in this capillary-range by using the centrifuge, and these show a correlation with beating times[5,6], but true equilibrium was probably not attained. Also, in centrifuging, the increased gravitational field directly affects the packing of the fibres themselves, whereas, on the wire of the paper-machine, the water drains away under gravity and is drawn out at the table rolls and suction boxes, so that the mat itself is subjected only to the normal gravitational pull, except for the hydrostatic tension of the water in the capillary spaces.

The porous plate technique, described in the preceding communication, affords a simple and reliable method of maintaining relative humidities very close to saturation, since the liquid tension is thermodynamically linked with the vapour pressure of the capillary water[7]. The distribution of pore size depends on the initial packing of the fibres in the mat, and a method had therefore to be evolved which assured a controlled and reproducible formation. Using this technique, curves of moisture content against hydrostatic tension were obtained on an easy-bleaching sulphate pulp which had been beaten for various times in the Lampén mill[8]. The results are given in Fig. 1. The curves all show hysteresis between desorption and adsorption, but for the sake of clarity the adsorption curve is shown only for the unbeaten sample. For the same reason, the desorption curves for the intermediate beating times are not shown at low tensions. It will be seen that at

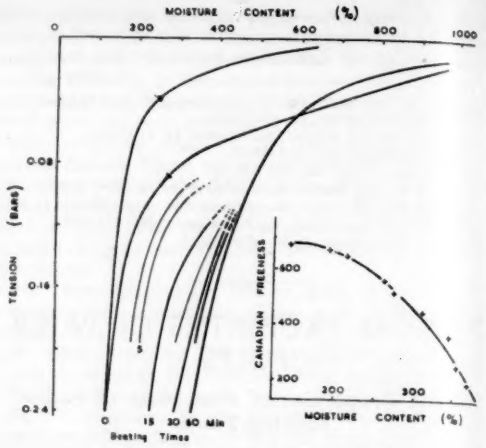

Fig. 1 Fig. 2

the higher tensions the desorption curves are very similar in shape and are displaced parallel to the moisture-content axis according to the time of beating. Thus any arbitrary tension may be taken as standard (for example, 14 cm. mercury = 0·187 bar). In Fig. 2 the desorption moisture contents at this tension are plotted against the Canadian freeness figure. The general correlation is seen to be satisfactory.

The porous plate technique is a static method, but the Canadian test is dynamic and therefore involves the rate of percolation of the water through the fibre mat rather than the tenacity with which the water is held. It may be argued on this basis that the porous plate method gives more direct information about the properties of the pulp from which the paper is eventually made. However, the rate of drainage is itself an important factor in paper-making since, on the machine, the water in the paper web may have no more than a few seconds in which to drain through the machine wire.

The main interest attached to these experiments is that they give, probably for the first time, a measure of wetness or freeness in exact thermodynamic terms, and that the data so obtained when used in conjunction with other experimental results described in the preceding communication may give precise information about the properties of the wet paper web under the conditions of manufacture.

One of us (R. H.) holds a research fellowship of the Norwegian Forestry and Forest Industries Research Organization.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Effect of High-energy Radiation on Long-chain Polymers

A NUMBER of long-chain polymers, when subjected to high-energy radiation such as is provided in the B.E.P.O. pile at Harwell, are found to become cross-linked. Among the polymers which behave in this way may be mentioned polythene, polystyrene, 'Terylene', nylon and unvulcanized rubber. In other polymers, for example, methyl methacrylate, decomposition sets in after a very short irradiation period.

The degree of cross-linking produced in these polymers is proportional to the radiation dose over a wide range of values, so that it is possible to prepare specimens of any required degree of cross-linking without the introduction of foreign atoms or heat treatment. Apart from its commercial implications, this treatment offers considerable advantages in the study of long-chain polymeric structure, and in the investigation of rubber-like elasticity.

Principal attention has been given to the changes in properties of polythene when cross-linked. Above a certain short irradiation dose, corresponding to about two cross-links per molecule, polythene becomes insoluble in organic compounds, and no longer melts even at temperatures considerably above 120° C. After greater irradiation doses polythene becomes somewhat more elastic, and cold flow is largely suppressed at room temperatures, while above the usual melting temperature it acquires rubber-like elasticity. When subjected to considerable radiation, polythene becomes completely amorphous, hard and glass-like in character, even at room temperature.

Above 120° C., Young's modulus for cross-linked polythene is found to obey the theoretical law of rubber-like elasticity both so far as the variation with temperature and with degree of cross-linking is concerned. This enables one to obtain a relationship between the radiation dosage and resultant cross-linkage produced. Similar results are obtained when the amount of radiation needed to produce insolubility is determined.

During irradiation of polythene, gases are emitted, consisting mainly of hydrogen, with smaller amounts of methane, ethane, etc. In addition, surface oxidation takes place when the irradiation takes place in air. The weight changes ΔM depend on the radiation dosage R, and on the initial mass M and surface area A of the specimen :

$$\Delta M = -\alpha_1 MR + \alpha_2 MR^2 + \beta_1 AR + \beta_2 AR^2,$$

where α_1, α_2, β_1, β_2 are constants ; α_2 is very small.

This formula is explained in terms of a volume evolution of hydrogen (α_1), a surface oxidation (β_1), and evolution of paraffinic gases from near the surface only (β_2). As a result, values for the probability of breaking of C—H and C—C bonds have been derived[2].

The density of cross-linked polythene in the amorphous state (that is, above about 115° C.) has also been investigated. It is found that the variation of volume V per gram with temperature T and degree of cross-linking c can be expressed in a form very reminiscent of the Van der Waals equation for a gas :

$$\left\{P + \frac{P_0}{1 - \beta c}\right\} (V - V_0) = RT/M,$$

where $\beta \sim 1$, P_0 is the internal pressure, and V_0 is a constant independent of c. The values of V_0 and P_0 are very close to those found by Spencer and Gilmore[1] in their studies of compressibility of ordinary polythene above the melting point.

Among other problems which may be mentioned is a study of the relationship between the degree of cross-linking and the swelling ratio for cross-linked polystyrene in benzene. This and other work will be reported in fuller detail elsewhere.

I wish to thank the Director, Atomic Energy Research Establishment, and Dr. H. M. Finniston, head of the Metallurgy Division, for permission to carry out this work and to publish the results.

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June 20.

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A New Focusing Principle applied to the Proton Linear Accelerator

A NEW design of synchrotron magnet has been announced recently by the bevatron group at Brookhaven[1]. It is stated that the novel focusing principle involved is applicable also to linear accelerators, but details are not given as to how the necessary apparatus is to be incorporated into an efficient radio-frequency accelerating structure. We wish to point out that there is only a minimum of interference with the radio-frequency system if the necessary fields are set up in the drift-tubes of a Berkeley-type accelerator[2] ; and in particular that, if electric rather than magnetic fields are used, then a rather simple modification of the drift tubes is all that is required.

The fields considered strongly focus the particles in one direction transverse to the motion, but defocus them in the direction at right angles. Overall focusing can result if these two planes are interchanged periodically along the accelerator ; this is the discovery of the Brookhaven group. Alternatively, the field structure could be made to spiral more or less continuously along the machine.

A method of applying electric fields is illustrated in Fig. 1. The drift-tube is divided by four longitudinal gaps and a potential difference applied between adjacent quadrants. If the gaps are small, the radio-frequency field will not penetrate to the centre of the tube, so that the shielding action of the latter

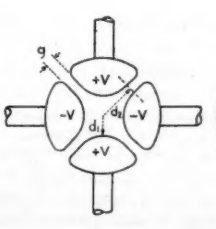

Fig. 1

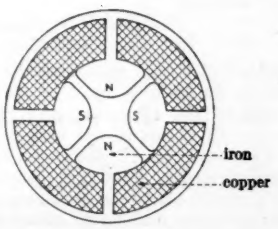

Fig. 2

is unimpaired. The inner surfaces are shaped as rectangular hyperbolæ to provide a better field distribution; at the drift-tube ends it might be desirable to change this shape, or to use guard rings, to avoid asymmetries in the radio-frequency radial forces.

My calculations indicate that with $d_1 = 1$ cm., $d_2 = 2$ cm., $g = 0{\cdot}5$ cm., and V of order 6 kV., we should be able to focus protons of energy about 45 MeV. or more in an accelerator with synchronous phase 30°, operating frequency 200 Mc./s., and accelerating rate 2·3 MeV./metre. The field would be alternated every three or four drift-tubes. With the same accelerating rate and lower velocities, the radio-frequency defocusing forces are larger, and correspondingly greater potentials are needed. These can be avoided if the accelerating field is reduced in the initial part of the machine; or alternatively, grid focusing might be used in this section.

Protons of 45 MeV. travel with almost one-third the velocity of light ($\beta = 0{\cdot}3$). The electric field of 24 kV./cm. can then be replaced by a magnetic field of 270 gauss. This is to be established over the 0·5-cm. gap in Fig. 2. The current needed is 107 amp. per quadrant; with 10 sq. cm. of copper winding in each quadrant and a space factor of 0·75, the power dissipation is 1·2 watts per metre of drift-tube. With the same accelerating rate at lower velocity, the magnetic field required is larger; if only the current in the coils is changed, then the dissipation per unit length varies inversely as the fourth power of the velocity.

The divided drift-tube for electrostatic focusing is the outcome of an idea pursued by us for some time which involved the introduction of a charged conductor into the ordinary tube. I am indebted to my colleagues for much valuable discussion of all these methods. The Director of the Atomic Energy Establishment is thanked for permission to publish this communication.

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Nov. 3.

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A 'Zero' Synthesis for Fourier Refinements

In the determination of crystal structure by means of X-ray diffraction data, the Fourier method[1] has long enjoyed the foremost place. Attempts have been made to substitute purely analytical techniques[2] depending upon either (*a*) the direct solution of the structure factor equations:

$$F_0(h,k,l) = \sum_r f_r \exp i\,\theta_r, \qquad (1)$$

where f_r is atomic scattering factor of r^{th} atom, θ_r is $2\pi(hx_r/a + ky_r/b + lz_r/c)$, $(x_ry_rz_r)$ are co-ordinates of the r^{th} atom, and the summation extends over all atoms in the unit cell; or (*b*) by means of a process[3] which attempts to minimize the difference between some non-negative sum function of the difference between the observed structure factor amplitudes and those calculated on the basis of an assumed approximate structure, for example:

$$\sum_{h,k,l} (\,|F_0| - |F_c|\,)^2, \qquad (2)$$

$|F_0|$ and $|F_c|$ being respectively the observed and calculated structure amplitudes.

When the system of equations (1) is taken as the basis of solution, an immediate difficulty lies in the fact that only the modulus of F_0 is known *a priori*, so that the relatively simple equations (1) have to be replaced by a more complex set obtained by separation of real and imaginary parts and subsequent squaring. Despite these difficulties, formal analytical techniques have been devised[1] for handling the solution; these, however, depend (in general) upon obtaining large runs of observations having, say, fixed k and l values and consecutive h, which are not usually available.

It is clear that in principle the problem posed by the equations (1) should be solvable given any set of $F_0(h,k,l)$ values having at least $3n$ members, n being the number of independent atoms in the unit cell. Actual sets of experimental data would be almost invariably grossly redundant when considered from this point of view, and it is interesting to consider if any method of solution exists in this case.

The general case, in which all phases are known, is, of course, trivial, since a straightforward Fourier synthesis

$$\rho(xyz) = \frac{1}{V}\sum_3 |F_0| \cos(\theta - \alpha) \qquad (3)$$

gives a density map the maxima of which occur at the roots of the set of equations (1). In two other cases, however, phase-angle data are available: (*a*) in those planes of which the phase is given by inequality theory; (*b*) in those planes of which the observed magnitude is zero. It is the second of these cases to which particular attention is to be directed in this communication, not only because of the ease with which such observations (or rather lack of them) can be obtained but also on account of the possible removal of ambiguity produced by the implied knowledge of phase.

At first sight, an application of the Fourier method to such a set of observations looks unpromising, since they are all zero; however, when the difference synthesis is considered, a more hopeful situation is apparent. It has been shown[4] that the synthesis:

$$(\rho_0 - \rho_c) = \frac{1}{V}\sum_3 (\,|F_0| - |F_c|\,)\cos(\theta - \alpha_c) \qquad (4)$$

has the property that if the positions of the $(x_ry_rz_r)$ used to calculate α_c, $|F_c|$ are marked upon it, the directions of steepest ascent at these points give the directions in which the $(x_ry_rz_r)$ must be moved in order to bring the trial structure into better agreement with the true one, and that magnitudes of shift can be estimated by a slightly more detailed analysis.

The reasoning of the original paper (*loc. cit.*) is still valid when $|F_0|$ is zero, and when only those terms for zero $|F_0|$ are included in the summation; thus the simplified expression:

$$\rho_c = \frac{1}{V}\sum_3{}'' |F_c| \cos(\theta - \alpha_c), \qquad (5)$$

where $''$ indicates that only those planes for which $|F_0|$ are zero are included in the $\sum_3$, will give the directions in which the atoms of a trial structure

must be moved in order to produce the most rapid convergence to a true structure.

It is not to be expected that such a refinement technique will lead to very precise co-ordinates, since to say that $|F_0|$ is zero can, in fact, mean only that it is less than some arbitrary lower limit of size. However, in view of the great ease of obtaining the observational material, it is suggested that the above technique may prove a useful addition to the existing armament of structure analysis.

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Internal Stresses caused by Disorder in Vitreous Materials

IT is now generally recognized that one of the main characteristics of a vitreous material is that its atomic structure has no long-range order[1]. This means that the individual interatomic bonds will not have the length and direction which they have in a crystal, and, because of this, these bonds will not have their normal strength. If it is assumed that the bonds within a certain small region are subjected to a similar distortion, then it will be correct to think of this region as being subjected to a mechanical stress. It is of some interest to calculate the order of magnitude of these internal stresses.

It is clear that the resultant of all the internal stresses in the material must be zero. One of the simplest cases of a distorted structure in which the internal stresses are balanced is the edge dislocation. The equations governing the stresses in such a dislocation have been derived by Nabarro[2]. It can be shown from his equations that the stresses near the centre of the dislocation are of the order of $2G/\pi$, where G is the shear modulus of the material. (It should be realized that this value is obtained from equations based on the assumption that Hooke's law applies for strains of the order of those present in a dislocation; this is, of course, not strictly true.) It is reasonable to assume that regions exist in a typical glass where the distortion is of a type similar to that existing in an edge dislocation, that is, it is a shear distortion; and that the stresses resulting from this distortion will be of the same order as those in a simple edge dislocation.

One consequence of this assumption will now be examined. Griffith[3] has shown that the theoretical strength of glass is of the order of 1,000 kgm. per sq. mm. Now it has just been suggested that internal stresses may exist in glass which cannot be removed by annealing, and which may be of the order of $2G/\pi$. Taking a typical value of G for glass of $0{\cdot}25 \times 10^4$ kgm./sq. mm., the value for the internal stresses is calculated to be about 1,600 kgm./sq. mm. Of course, the internal stresses cannot be greater than the theoretical strength of the material. The values just given for the theoretical strength of glass and for the stresses due to disorder merely indicate the order of magnitude of these stresses; but the values obtained do suggest that, because of the large internal stresses of the material, it may be necessary to apply only a relatively small external stress to cause fracture of the material. It is therefore suggested that the relatively low breaking strength of glass may be partly due to its disordered structure; but it is realized, of course, that in massive glass articles (bottles, sheet glass, and so forth) at least, the flaws in the material which are always present as a result of the manufacturing process and the handling of the article in service may also have a marked effect on the strength.

The expression for the maximum stress of the centre of a dislocation suggests that there may be some relationship between the tensile strength and the shear modulus of glass. This is confirmed, to some extent, by experiment. Thus Murgatroyd[4] has found that, for fibres of a soda lime silica glass between 10 and 100 microns in diameter, the tensile strength increases with decreasing diameter and, at the same time, the shear modulus decreases. This is in agreement with the views just put forward; a decrease in the shear modulus will cause a decrease in the stresses due to disorder, so that a larger external stress will have to be applied for the internal stresses to reach the theoretical strength of the glass. If it is assumed that the greatest internal stress is given by the expression $2G/\pi$, then it is found that the sum of the greatest internal stress and the applied breaking stress is almost constant. This is shown by the results given in the accompanying table.

Fibre dia. (μ)	G (10^4 kgm./sq. cm.)	Max. internal stress $= 2G/\pi$ (10^4 kgm./sq. cm.)	Applied breaking stress (10^4 kgm./sq. cm.)	Max. internal stress + applied breaking stress (10^4 kgm./sq. cm.)
40	2·49	1·585	0·170	1·755
80	2·63	1·675	0·100	1·775
110	2·68	1·705	0·070	1·775

Other measurements which have been carried out on finer fibres of fused silica are not consistent among themselves. Thus Reinkober[5] has found that, for silica fibres of diameter less than 20 microns, there is a rapid increase in the shear modulus with decreasing fibre diameter, whereas Eberhardt, Kern and Klumb[6] have found that for silica fibres of the same diameter there is a slight decrease in shear modulus with decrease in diameter.

I am indebted to Mr. J. E. Stanworth, of this laboratory, for a number of useful discussions during the preparation of this communication; I am also indebted to Mr. L. J. Davies, director of research, British Thomson-Houston Co., Ltd., for permission to publish the work.

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Closed Pores in Synthetic Graphite

It is well known that the bulk density of a synthetic graphite is much lower than the density of the crystallites obtained from X-ray measurement: 25–30 per cent of the volume must be empty pore space. By measurement of the real density with three different fluids, we have shown that about 20 per cent of the total pore space cannot be reached by a liquid or gas unless the graphite is reduced to a very fine particle-size, or part of the structure is removed by oxidation.

The synthetic graphites studied were pure grades (99·9 per cent carbon), prepared in a commercial graphitizing furnace, having a bulk density of 1·6 gm./cm.³. The displacing fluids used for density measurements were methanol, *n*-hexane and helium. The liquid densities were measured after prolonged refluxing in the liquid used. The standard density-bottle method was used for specimens 6 mm. or less in diameter, and larger specimens were weighed in air and in liquid. The densities of helium were measured after outgassing at 300° C. to a pressure of 10^{-4} mm. of mercury or less; no measurements were taken until two hours after admitting helium, and measurable drifts with time were seldom recorded after that period. The results are considered accurate to ± 0·3 per cent.

In all cases where they were directly compared, the liquid and helium densities agreed closely. For example, the density of a cylinder (15 mm. diameter) of synthetic graphite was measured as 2·091 gm./cm.³ in *n*-hexane and as 2·093 gm./cm.³ in helium after pumping off the hexane; the density of an oxidized dust was 2·224 and 2·220 gm./cm.³ in methanol and helium respectively. There was no evidence of a molecular sieve effect, as has been reported for some cokes[1], that is, the measured density was independent of the molecular size of the displacing fluid.

The density of pure flakes of natural Ceylon graphite (99·5 per cent carbon) was measured as 2·253 gm./cm.³ in methanol and 2·251 gm./cm.³ in helium; these values amount to 99·3 per cent of the value derived from X-ray crystallographic data, which is[2,3] 2·266 gm./cm.³. In contrast to this, the densities of specimens of the synthetic graphite were always lower than 2·21 gm./cm.³. The densities of bulk specimens, that is, cylinders and plates, varied from 2·06 to 2·13 gm./cm.³ with no systematic variation with specimen size or with the original position of the specimen in the large manufactured block. The densities of dusts (particle diameter less than 0·4 mm.) milled from the same blocks as provided the bulk specimens were uniformly higher, ranging from 2·15 to 2·21 gm./cm.³, and these densities showed a tendency to increase as the particle-size of the dust decreased. For one dust examined, the sieve fraction − 36 + 72 B.S.S. had a density of 2·154 gm./cm.³, whereas the density of the fraction passing a 240 B.S. sieve was 2·191 gm./cm.³.

Thus all measured density values found for artificial graphite were 2–8·5 per cent lower than the experimentally determined value for natural graphite. The calculated X-ray density of a synthetic graphite comparable to that used by us (sample *A* 1, ref. 3) was only 0·2 per cent lower than the X-ray density of Ceylon graphite. The low observed densities therefore suggest the presence of inaccessible pore space in the micro-structure of synthetic graphite, formed either by the disordered stacking of the graphite crystallites or by intercrystalline linkages of non-graphitic carbon. Some of the blockages in the pores must be fairly far apart, since reducing the particle size to 70 microns opens up an appreciable fraction of the closed space.

The densities of some bulk and dust samples were re-measured after oxidation at 430°–500° C. in an air stream. The density always increased on oxidation, the increase being normally greater the larger the loss of weight. The density increase was most marked in the initial stages of the oxidation—the density of a 14-mm. diameter cylinder increased from 2·130 to 2·194 gm./cm.³ on oxidation to 0·55 per cent loss of weight, and to 2·226 gm./cm.³ on oxidation to 2·7 per cent loss of weight. It is suggested that slight oxidation may remove the pore blockages, either by first removing poorly crystallized material, or by oxidation occurring first at the edges and corners of crystals, and closed spaces may thus become accessible to the measuring fluid.

The significance of these results will be more fully discussed in conjunction with parallel adsorption measurements to be reported elsewhere. We wish to acknowledge experimental assistance afforded by Mr. E. A. Harper and Mr. H. Small, of this Establishment.

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Morphology of Crystalline Synthetic Polymers

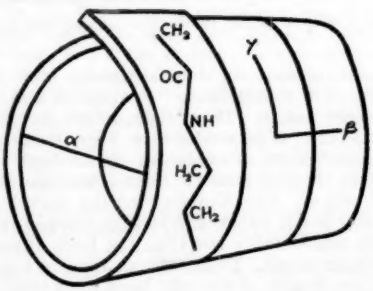
In a previous communication[1], it has been reported that when polyethylene terephthalate crystallizes, it forms spherulites, which consist of radiating helically wound ribbons, and that other synthetic polymers behave similarly. The present communication describes effects observed with polyethylene and polyamides.

In order to observe the phenomena to be described, polyethylene and polyamide (nylon) melts were crystallized in thin layers between cover-glasses at a constant temperature within 20° C. of the softening point. Between crossed Nicols, spherulites were seen which, in addition to the usual black cross, showed a system of concentric extinction rings, and in some cases also the beginning of a zig-zag distortion of the crosses[1]. With decreasing temperature of crystallization, the extinction rings become gradually narrower and more closely spaced, until they can no longer be resolved with the optical microscope. The sign of birefringence of the polyethylene spherulites was negative, and that of the polyamides nearly always positive; by this it is meant that, regarding the spherulite as uniaxial, in the first case the major refractive index lies tangentially and in the second radially with respect to the spherulite. In very rare instances isolated negative polyamide spherulites have been seen, but the conditions for producing these are not known. All these effects can be explained by the morphology proposed in ref. 1. Accordingly, the above observations correspond to cases in which the radiating needles are closely coiled helices (helical angle only a few degrees), and the increasing separa-

tion of the rings with increasing temperature of crystallization would be due to the increasing diameter of the needles.

Thinner layers of melt crystallize to a felted mass of interpenetrating needles, which aggregate into airscrew-like structures with voids between. Still thinner layers produced isolated needles which direct observation showed to be helically coiled ribbons, as postulated from the extinction pattern.

Some conclusions could be reached about the orientation of the molecules within the ribbons themselves. It will be assumed that the chains are parallel to the length of the ribbons, as this is consistent with our ideas about aggregation of fibre-forming molecules. Owing to the close coiling, γ, the largest refractive index (coincident with the chain direction), will be perpendicular to the helical axis. In polyethylene, α and β, minor and intermediate refractive indices respectively, are nearly equal[2], whence the birefringence of the spherulites will be negative as observed. In polyamides the conditions are complicated by the fact that β is more nearly equal to γ than to α, as a result of the strong polarizability of the CO- and NH-bonds[3]. We assume that the hydrogen bonds lie in the plane of the ribbon, as this is most likely in view of the crystal structure[3]. Then if the ribbon is closely coiled so that its plane is parallel to the axis of the helix, the position of the refractive indices will be as shown in the diagram. When the same beam of light goes through a number of helices, γ and α will be averaged, the resultant being smaller[3] than β, which lies along the axis of the helix, and hence along the radius of the spherulite. Consequently, the birefringence will be positive as observed.



Schematic illustration of the arrangement of the molecules and the refractive indices of a polyamide within a helix

An X-ray photograph has been taken of a circular area 30 μ in diameter near the periphery of a spherulite of polyhexamethylene sebacamide, using the microbeam method of Herbst[4]. The diameter of the spherulite was 200 μ and the thickness 20 μ. The photograph showed that the planes containing the hydrogen bonds were parallel to the radius, and that the molecules were arranged tangentially. This picture is the same as that deduced from birefringence evidence. These X-ray findings differ from those of Herbst, who concluded that the hydrogen-bonded planes were perpendicular to the radius. Such an arrangement would give a negative sign of birefringence; but Herbst's note does not contain any statement about the birefringence.

The picture of the radiating helices has now been proved in several ways, and the frequent special case when the helices are closely coiled gives a satisfactory morphological explanation of the hitherto unexplained tangential molecular orientation often described in the literature of polymer spherulites.

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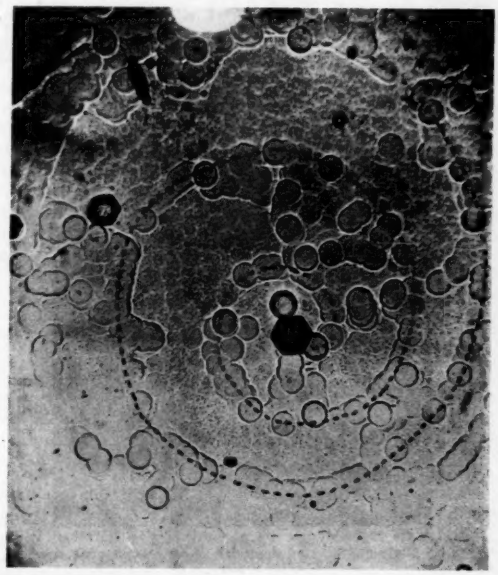
Etch-pits and Dislocations

Prof. S. Tolansky and M. Omar have reported[1] the appearance of spirals on octahedral faces of diamond, after etching. The hypothesis was put forward that etch-pits had been formed along a spiral-shaped growth-front; but no proof was given.

In the course of a detailed interferometric study of etch-pits, a report on which will be published elsewhere[2], we made very similar observations on *c*-faces of silicon carbide. Crystals on which growth-spirals were present were etched in fused borax and silvered before examination. It was found that etch-pits had been formed all along the spiral growth-fronts, proving the correctness of Tolansky's point of view.

The accompanying photograph shows the crystal face after etching; the original spiral (step-height of the order of 600 A.) has been marked by a broken line. At the end of the dislocation line a very deep etch-pit (several wave-lengths) was formed, proving that the presence of dislocations makes etching easier. This last point is also strikingly shown on prism faces (110) of very perfect topaz crystals, where etch-pits form preferentially at the top of growth pyramids.



These observations suggest that etching at dislocations will take place following a mechanism which is formally analogous to the Frank mechanism for growth[3]. A striking feature is the difference between the deep polygonized etch-pits generated at the emergence of screw dislocations and the shallow rounded etch-pits formed elsewhere on apparently perfect areas of the crystal face.

This work is part of a research scheme supported by I.R.S.I.A. I wish to thank Prof. W. Dekeyser and Dr. S. Amelinckx for advice.

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Exudation of Material from Slip Bands at the Surface of Fatigued Crystals of an Aluminium–Copper Alloy

No satisfactory explanation of the fatigue mechanism of metals has yet been advanced. The generally accepted idea involving work-hardening and subsequent 'brittle' fracture cannot be substantiated by observation as being the only cause of fatigue failure. Observations I have made on pure aluminium and aluminium–$\frac{1}{2}$ per cent silver specimens have shown that the mechanisms of failure at high and low stresses are fundamentally different[1].

A type of crystal breakdown which it is believed has not been observed before, and which may contribute to the understanding of the initiation of fatigue cracks, has recently been observed during the fatiguing of an aluminium–4 per cent copper alloy in the solution heat-treated condition. During the early stages of the fatigue life of this material, some of the grains become covered with fine slip bands, as is usual with most of the materials examined. The new observation is that, as the cyclic stressing continues, certain slip bands become more heavily defined, and thin ribbons of material are exuded from these bands. These ribbons usually curl over at the leading edge as shown in Figs. 1 and 2. It is only possible to estimate an upper limit for the thickness of the exuded ribbon because of these curled edges. The diameter of the curled portion is usually about 1 micron; thus the ribbon thickness may be considerably less than the limit of resolution of the microscope. These ribbons may be continuous along the length of the slip band, but they usually break into shorter lengths. The wrinkled appearance of these short lengths suggests that the 'extrusion-rate' is varying along the band. These ribbons often

Fig. 1. Surface of fatigued aluminium–4 per cent copper specimen. × 500

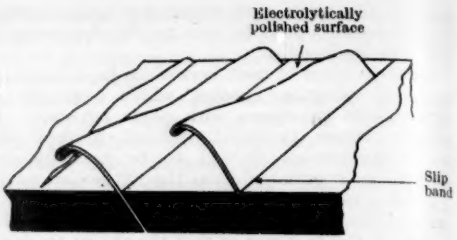

Fig. 2. Schematic diagram showing crystal debris at surface of crystal

Fig. 3. Ribbon of exuded material showing 'extrusion' markings. × 1,500

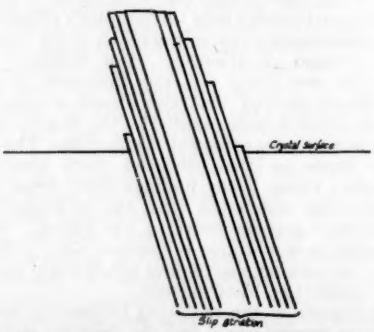

Fig. 4. Schematic diagram of a slip striation in which a layer of material may be exuded from the crystal surface

showed 'extrusion' markings as indicated in Fig. 3, and often other markings at right-angles to these are also observed.

The effect of the loss of this coherent material from the crystal surface must be to leave crevasses which will form very effective stress raisers. The mechanism by which this material is exuded from the surface is not clear, but it may be the result of slip movements as suggested in Fig. 4. Further investigations into this phenomenon are being made.

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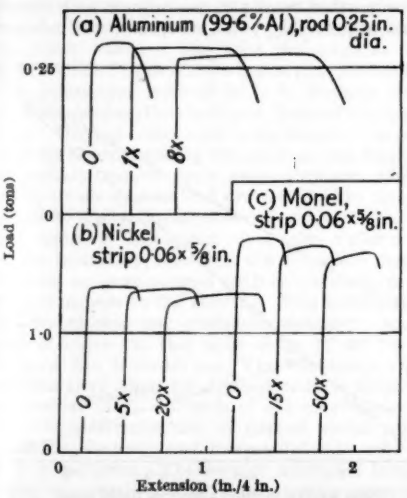
Softening of Cold-worked Metals under Cyclic Strains

IT is well known that ductile metals in the soft condition work-harden progressively when subject to cyclic straining, for example, in fatigue testing. On the other hand, I have shown[1] that metals originally cold-worked soften when plastically deformed under conditions in which a Bauschinger effect is operative. Since a Bauschinger effect is to be expected whenever the original and superimposed methods of deformation differ, it can be anticipated that initially cold-reduced metals may soften when later exposed to cyclic plastic strains. This is confirmed by the following experiments (see graph).

Diagram (*a*) refers to a rod initially cold-drawn 15·6 per cent, and in the as-drawn condition extension curve *O* was obtained. After an additional single reversed torsion cycle of 0 ± 45° per in. of length, the extensometer record altered to 1 ×, and after eight such cycles curve 8 × was recorded.

The nickel and Monel strips (*b*, *c*) were first cold-rolled 20 per cent and afterwards bent forwards and backwards over a 4-in. diameter cylinder. Curves 0 refer to the as-rolled condition. The others were obtained after subjecting the strips to the indicated numbers of reversed bending cycles.



Effect of reversed torsion cycles (*a*) and reversed bending (*b*, *c*) on tensile properties of certain cold-worked metals

There was a fall of surface hardness, yield and tensile values in each case, and a pronounced increase of elongation in most cases. Similar results were obtained with copper and carbon steel and for initial reductions up to 60 per cent (to be reported in detail elsewhere). Relevant effects noted in industrial straightening of rod and wire[2] can thus be accounted for on a rational basis.

Thanks are due to Mr. H. W. G. Hignett (The Mond Nickel Co., Ltd., Birmingham) for presenting samples of nickel and 'Monel' metal.

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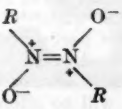
Perfluoroalkyl Nitroso Compounds

A PRELIMINARY study[1] of the photochemical properties of the first fluorocarbon iodide, trifluoroiodomethane, showed that a trifluoromethyl radical is produced the primary reactions of which parallel those of the hydrocarbon free radicals. A direct method thus became available for the preparation of perfluoroalkyl nitroso compounds, by irradiation of the iodide in the presence of nitric oxide and of mercury (to remove iodine), with the difference that the product would then be stable, in contrast to alkyl nitroso compounds, which dimerize, and re-arrange to form oximes[2]. (Ruff and Giese[3] had previously reported as a by-product of the action of elementary fluorine on silver cyanide containing the oxide and nitrate as impurities, a 1 : 1 mixture of CF_3NO and $FCONF_2$, from which the former could not be separated. Some properties and reactions were recorded, not all of which agree with the present work, or with what one would expect of the compound perfluoroformamide.)

Assuming, as seems likely, that the aliphatic nitroso compound dimers have the same constitution as their aromatic analogues, the structures of which are known[4], dimerization would here be inhibited by the strong inductive pull of the perfluoroalkyl group (cf. Pauling's adjacent charge rule[5]), and isomerization to form the aldoxime analogue would be impossible with the electronegative fluorine replacing hydrogen.

(two forms), with some contribution from



Perfluoro-1-nitrosopropane has been made by irradiating gas mixtures, at just below atmospheric pressure, of perfluoro-*n*-propyl iodide and nitric oxide (with a slight excess of the latter) in a silica bulb of 220 c.c. capacity containing about 5 c.c. of

mercury. Osram high-pressure mercury vapour lamps (type *MB/V*, 125-watt, with the glass envelope removed) were used as sources of ultra-violet light. Purification of the gas was found to be difficult, but was effected by repeated distillation in a Fenske-packed column, with reflux temperature − 78·5°, middle cuts being taken. The pure nitroso compound, obtained in *c.* 80 per cent yield from the iodide, is a gas of very deep blue colour tinged with green; the liquid is deep blue, and the solid almost purple.

Preliminary values for the physical constants were measured on samples of which the molecular weight, determined by the gas density method, was within 1 per cent of 199, the theoretical value.

Saturation vapour pressures are given by

$$\log P \text{ (mm.)} = 9{\cdot}035 - 1{,}593/T,$$

according to which the boiling point (extrapolated) is − 14·5° C., the latent heat of evaporation at the boiling point 7,270 cal., and the Trouton constant 28, suggesting that the liquid is strongly associated. The melting point was determined in a Stock apparatus as − 151° C. Analysis by the calcium fluoride method, after sodium fusion, gave 66·1 per cent fluorine (theoretical value, 66·8 per cent).

The spectrum of the gas was measured at room temperature, with a transmission-reading Cary recording spectrophotometer. The vapour was contained in a 4-cm. silica cell, filled to pressures between 5 and 75 cm. of mercury.

The blue colour of the gas is due to a very weak absorption band, for which $\varepsilon_{max.} = 19{\cdot}0$ at 6840 A., of oscillator strength (*f*-value) 0·00020 in the red. This band is markedly asymmetrical, but apart from six irregularly spaced and very poorly resolved vibrational bands, is almost structureless. The following are representative of the spectral slit-widths used in this region: 45 A. at 7000 A., 17 A. at 6500 A., 7 A. at 6000 A.

A region of more intense absorption begins at 2400 A. Between these two chief band systems there was invariably very weak banded absorption (ε less than 0·2), the intensity of which varied from sample to sample, and which is therefore confidently ascribed to small and variable quantities of impurity.

This spectrum closely resembles that of di*iso*propyl bromonitrosomethane given by G. N. Lewis and M. Kasha[4] over a similar range, and those of other α-substituted aliphatic nitroso compounds observed in the visible region by D. Ll. Hammick *et al.*[7].

The liquid, in a sealed tube at room temperature, was found by the Gouy method to be diamagnetic (cf. nitrosyl chloride[5,9], nitrosobenzene[10]), and the molecular susceptibility agrees, within an experimental error of some 5–10 per cent, with the sum of the atomic susceptibilities (− 102 × 10^{-6} c.g.s.u.). The magnetic and optical properties support the formulation of C_2F_7NO as a nitroso compound, in a singlet state[6,8,11].

The perfluoroalkyl nitroso compounds are readily oxidized, and are completely absorbed in alkali. Further studies of these compounds are in progress and will be offered for publication elsewhere.

I wish to thank Dr. I. G. Ross for measuring and commenting on the spectrum, Imperial Chemical Industries, Ltd. (General Chemicals Division), and the Minnesota Mining and Manufacturing Company, St. Paul, Minnesota, for gifts of fluorochemicals, and members of the Department of Chemistry (including Dr. N. Kornblum) at University College for help and encouragement.

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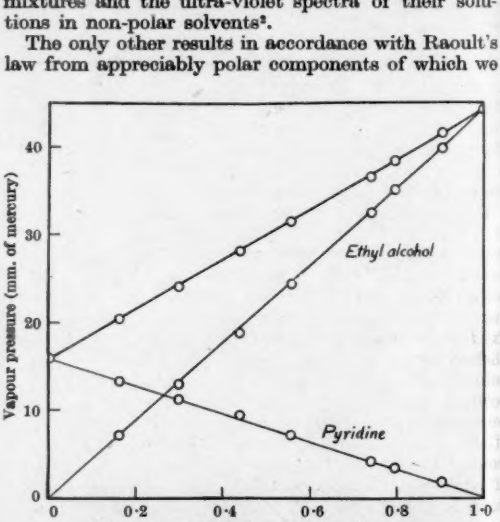
Raoult's Law: a Pseudo-Ideal System

Relatively few binary liquid mixtures obey Raoult's law in their vapour pressure relationships. Most of those which do so are mixtures of either isomers or close homologues. The components of the remainder are not, in general, highly polar substances[1].

In the course of other investigations, we have had occasion to measure the total and partial vapour pressures at 20° of the system pyridine – ethyl alcohol. The results (see graph) approximate closely to the behaviour required by Raoult's law. In this system, however, not only is association of one component (ethyl alcohol) possible, but also there can be intermolecular attraction, by hydrogen-bonding, between the two components. Evidence that such hydrogen-bonding does occur (to give a 1 : 1 molecular compound) is provided by the Raman spectra of the mixtures and the ultra-violet spectra of their solutions in non-polar solvents[2].

The only other results in accordance with Raoult's law from appreciably polar components of which we



Total and partial vapour pressures in the system pyridine-ethyl alcohol

are aware are from an isobaric investigation of the system pyridine – acetic anhydride[3]. Here, however, there is no free hydrogen atom to allow of the extensive hydrogen-bonding which can occur between pyridine and ethyl alcohol.

It is interesting to note that the total pressure curves for the system pyridine – ethyl alcohol at 0° and at 40° show no deviation from linearity, within the limitations of the method used[4].

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Moving-Boundary Electrophoresis of Colloidal Electrolytes using Concentration Boundaries

Owing to the difficulty of finding sufficiently slow indicator ions, it is doubtful if the direct moving-boundary method for transference numbers can be fully applied to solutions of colloidal electrolytes. Hartley's 'balanced' boundary method[1], in which the colloidal ion forms the indicator ion, involves the determination of 'Kohlrausch concentrations' and a knowledge of the transference number of the leading ion.

The differential method, in which a boundary is formed between two concentrations of the same electrolyte, reveals the change in transference number between these concentrations across the boundary. Smith[2] and Longsworth[3] have shown that the transference number increments thus obtained with ordinary salts agree well with those from the direct moving-boundary method.

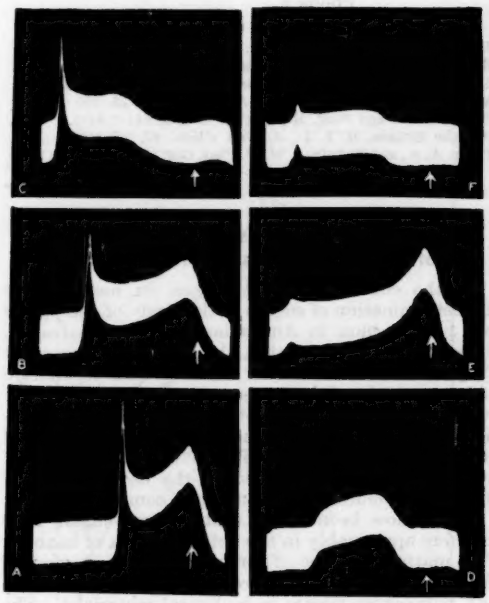
We have applied this to potassium laurate and lauryl sulphonic acid solutions at 0·5° C. For potassium laurate solutions, an excess of 4 equiv. per cent of potassium hydroxide on the basis of soap was added in the concentrated solution to prevent hydrolysis. The concentration of potassium hydroxide in the dilute solution was kept the same as in the stronger solution to prevent a concentration boundary due to potassium hydroxide. A Tiselius electrophoresis apparatus (Perkin Elmer Model 38 [4]), utilizing a 2-c.c. Tiselius cell and Longsworth's scanning method for photographing boundaries, was employed.

Preliminary results have been obtained with the 'open' electrode system and are reported in this communication. For accurate determination of the transference number increment over the interval ΔC across the boundary, however, the boundary displacements need to be measured with reference to a plane fixed with respect to the solvent. This is best accomplished by closing one electrode chamber, so that volume changes on this side alone affect the disposition of the boundaries. The necessary volume corrections may then be applied with a knowledge of the partial molal volumes of the electrolyte solutions. The determination of partial molal volumes of potassium laurate and laurylsulphonic acid solutions is in progress. The results described here are, however, of interest in that concentration boundaries have been used for the first time to investigate 'association' colloids.

Three concentration boundary systems were investigated for potassium laurate solutions. (1) Both solutions were below the critical concentration for micelle formation. The boundaries in the two limbs of the Tiselius cell moved towards each other irrespective of the direction of current. This was possibly due to convective flow caused by a great disparity of heat generated in the two solutions across the boundary. Similar phenomena have been observed by Smith[2] and Longsworth[3] with concentration boundaries involving simple electrolytes. (2) The dilute solution was fixed at a concentration (c'') of 0·25 per cent and the concentrated solution (c') varied from 0·7 to 2·00 per cent. The anion transference number increment ($T_{c'} - T_{c''}$) showed a sharp rise when c' exceeded the critical concentration for micelle formation. (3) The concentrated solution was fixed at 2·0 per cent and the dilute solution varied from 0·25 to 1·50 per cent. The boundaries moved in the opposite direction to the positive current and the anion transference number increment ($T_{c'} - T_{c''}$) showed a maximum in the region of c'' (equal to critical concentration for micelle formation).

Further experiments were carried out with boundary systems in which the dilute solution was fixed at a concentration corresponding to the critical concentration for micelle formation, being 0·83 per cent (0·035 *M*) and 0·25 per cent (0·010 *M*) for potassium laurate and laurylsulphonic acid solutions, respectively[5].

These boundary systems have a special significance in that the increments of anion transference number thus obtained represent the transport due to the associated colloid ion or ions. The anion transference



Moving boundary electrophoresis of colloidal electrolytes at 0·5°; ascending patterns. The arrow indicates the initial position of the boundary. The direction of current, 8 m.amp. in each case, is from left to right.
Potassium laurate solutions. (*A*) 3·00–0·83 per cent; 1,200 sec. (*B*) 3·00–0·83 per cent; 1,800 sec. (*C*) 2·00–0·83 per cent; 1,800 sec. (*D*) 2·00–1·00 per cent; 1,200 sec.
Laurylsulphonic acid solution. (*E*) 2·00–0·25 per cent; 1,200 sec. (*F*) 0·75–0·25 per cent; 1,200 sec.

number increment ($T_{c'} - T_{c.m.c.}$) passed through a maximum at $c' = 3{\cdot}0$ per cent ($0{\cdot}126\,M$) for potassium laurate and at $c' = 1{\cdot}5$ per cent ($0{\cdot}060\,M$) for laurylsulphonic acid solution[6]. These maxima correspond to concentrations at which the solutions have reached the fully colloidal state as shown, for example, by the solubilization of dyes by aqueous potassium laurate and laurylsulphonic acid[7].

The schlieren patterns obtained are of interest. There is a sharpening effect at the descending boundary which moves as a steady state almost from the moment the current is switched on. There is a spreading effect at the ascending boundary which splits into two component boundaries. This may, or may not, be due to the presence of more than one kind of colloidal particle. A few representative ascending patterns are illustrated in the accompanying photographs. It may be noted that the area under the faster component of the ascending pattern remains practically unchanged for either electrolyte over a considerable range of concentration. If, however, the concentration of the dilute solution across the boundary were increased from 0·83 to 1·00 per cent (for potassium laurate solutions), the faster boundary disappeared (compare patterns *C* and *D*). The faster boundary of the ascending pattern may therefore be due to a rapid increase of anion transference number over a narrow range of concentrations just above the critical concentration for micelle formation.

I am grateful to Prof. J. W. McBain and Dr. S. S. Marsden for their interest in this work.

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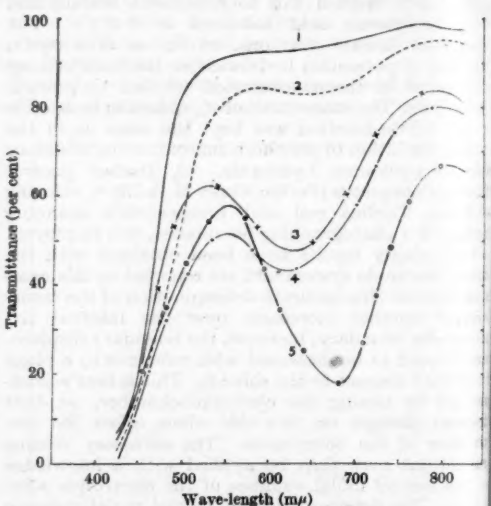
Interference of Pentose in the Estimation of Hexose Sugars with Anthrone

In the course of investigations on methods for the determination of sugars in the study of the trashy leaf phenomenon in Australian flue-cured tobacco[1], it was soon apparent that the anthrone reagent of Dreywood[2] was well suited to the routine estimation of hexose and polyhexose sugars in plant materials. It was found, however, that the quantitative estimation of sugars with anthrone requires rigid control of variables such as the rate of evolution of heat of hydration of sulphuric acid in the development of the green-coloured sugar–anthrone complexes.

It has now been found that pentose sugars may interfere appreciably in the determination of hexoses. This matter could be of some importance in view of the extensive use of anthrone in estimating hexose and polyhexose sugars in biological materials[3]. The colour intensity of the pentose–anthrone complex is negligible compared with that of the hexose–anthrone complex, when sugars are compared individually on an equimolecular basis. Anthrone might therefore be regarded as virtually specific for hexose and polyhexose sugars when applied to separate test solutions. This specificity does not apply when pentose and hexose are present in the same solution.

Absorption curves have been determined for analytical grade purity and recrystallized laboratory reagent hexose, dihexose and pentose sugars (that is, glucose, fructose, sorbose, sucrose, xylose, arabinose and ribose) and for pentose plus hexose solutions anthronated before and after mixing. Curves 1, 2 and 3 of the accompanying figure are typical spectral curves for anthrone reagent alone, pentoses (arabinose 100 μgm. per 12 ml.) and hexoses (glucose 50 μgm. per 12 ml.) respectively. Curve 4, typical for mixtures of pentoses and hexoses, was obtained when equal volumes of separately anthronated solutions of arabinose (200 μgm. per 12 ml.) and glucose (100 μgm. per 12 ml.) were cooled to 20° C. and mixed just before spectral measurements. Curve 5 was obtained when the pentose–hexose solutions were mixed before anthronation. The standard anthronation procedure adopted in this laboratory was followed in all cases. The spectral measurements were made on a Beckman spectrophotometer (model *D.U.*), and the coloured complexes obtained proved stable at room temperature, with no perceptible colour deterioration within 60 min. Curve 4 for the mixture of separately developed pentose–anthrone and hexose–anthrone complexes follows closely that of the hexose–anthrone complex (curve 3), with minimum transmittance at about 625 mμ, and appears to be the resultant of the two curves; whereas curve 5 (pentose–hexose–anthrone), obtained with the mixed sugars, differs markedly and shows maximum absorption at about 680 mμ. It is clear that, when pentoses and hexoses are anthronated together, a complex is formed of a very different nature from that formed when hexoses are anthronated alone.

The accompanying table presents values for glucose estimated by the anthrone technique in known mixtures of glucose with arabinose, using a Hilger absorptiometer with a filter of 620 mμ maximum transmittance. The 'error' expected from the inclu-



Absorption curves for sugar–anthrone complexes. (1) ———, anthrone reagent only; (2) - - - -, arabinose, 100 μgm. per 12 ml.; (3) —×—×, glucose 50 μgm. per 12 ml.; (4) —·—·, mixture of separately anthronated solutions containing complexes of 100 μgm. arabinose and 50 μgm. glucose in 12 ml.; (5) —○—○, complex of anthronated solution containing 100 μgm. arabinose and 50 μgm. glucose in 12 ml.

INTERFERENCE BY PENTOSE IN ESTIMATION OF HEXOSE SUGARS WITH ANTHRONE

Mixture of		Glucose found*	Error found expressed as glucose	Approximate error expected†
Arabinose (μgm.)	Glucose (μgm.)	(μgm.)	(μgm.)	(μgm.)
0	30	30	0	—
25	30	37	7	< 1
25	60	67	7	< 1
50	60	74	14	< 2
100	60	88	28	< 4
100	90	120	30	< 4
100	120	154	34	< 4
150	120	171	51	< 6

* Values read off a standard glucose graph. They are means of four separate estimates, each based on two duplicates. The 95 per cent confidence limits to these means are given by mean ± 1·2 per cent of the mean.

† Absorption readings for various amounts of anthronated pure arabinose read off the standard glucose graph and expressed as glucose

sion of the arabinose was determined by measuring the colour development from a pure arabinose solution, and expressing this in terms of glucose. It was found that 100 μgm. of arabinose gave a colour development equivalent to less than 4 μgm. of glucose. The errors actually observed in solutions containing both sugars were far greater than this, approaching 30 per cent when the molecular concentration of arabinose equals that of glucose.

This finding indicates that, when using the hexose–anthrone complex in hexose sugar estimation, any pentoses present should be corrected for or removed. The procedure adopted for separation of pentose and hexose sugars from their mixtures, and the quantitative estimation of both groups, will be published elsewhere.

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Liesegang Rings on Metallic Bases

WE have repeated the experiment described by Christomanos[1], and observe the formation of good Liesegang rings in all cases on clean, pure silver and other more noble metals; but either no rings, or badly distorted ones, on less noble metals and silver alloys. If the silver surface is previously darkened by exposure to sulphide, the rings are distorted but none the less appear in most cases. If, however, the clean metal is previously heated to darkening, or dipped in hydrogen peroxide solution, the rings that are eventually formed are decidedly inferior.

These observations suggest a modification of the normal ring formation by interruption of the straightforward precipitation of silver chromate, and appear to be compatible with the supersaturation theory rather than requiring an electrochemical explanation.

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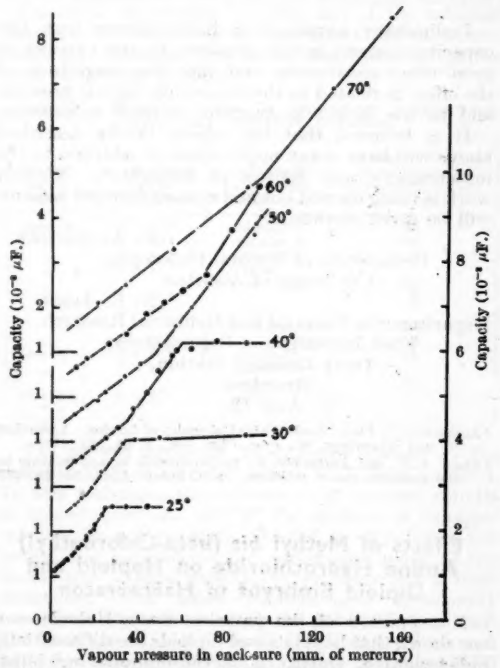
Effects of Water Vapour on the Electrical Properties of Anodized Aluminium

IN connexion with experiments on semiconductors, one of us[1] noted the very considerable change of capacity which took place when a condenser containing aluminium oxide as the dielectric material was placed in a system which was then evacuated. The change of capacity was ascribed to the removal of adsorbed water from the porous aluminium oxide. In the above investigation, the condenser consisted of an aluminium sheet, of an aluminium oxide layer formed electrolytically (by 'anodizing') on the sheet, and of a thin metallic layer of aluminium evaporated on to the oxide film. The aluminium sheet and the evaporated surface then formed the plates of the condenser.

We measured the capacity of a condenser formed in a similar fashion on an aluminium wire of commercial purity, of approximately 1/16 in. diameter, which was placed in an enclosure in which water vapour was admitted under controlled conditions. Some measurements of the leakage resistance of the condenser were made concurrently with the capacity measurements. A typical sample of useful length 3 cm. had a capacity of 1,200 pF. at zero humidity. The oxide layer was formed at 50 V. in a 3 per cent chromic acid bath. The thickness of the oxide film is estimated to be about 1 micron.

A family of curves relating the capacity of the condenser to water vapour pressure at various temperatures of the condenser is shown in the accompanying graph. Several features are worthy of comment: (1) each curve may be represented by two intersecting straight lines; (2) the initial



Variation of capacity with water vapour pressure in the enclosure for various temperatures of the element. (For clarity, the capacity ordinate of successive curves has been displaced one unit vertically)

straight line is in each case the same; (3) the maximum capacity is attained when the measured vapour pressure corresponds to the saturation vapour pressure at the temperature of the condenser; (4) the slope of each curve changes sharply when the vapour pressure approximates to half the saturation vapour pressure at the temperature of the condenser; (5) the slope of the second portion of each curve is almost identical.

The results for each set of points may be expressed in a non-dimensional form:

$$R_c = 0{\cdot}73\,R_H \quad \text{when } 0 < R_H < 0{\cdot}5 \quad 1(a)$$

$$R_c = 1{\cdot}12\,R_H - 0{\cdot}18 \quad \text{when } 0{\cdot}5 < R_H < 1 \quad 1(b)$$

where R_c is the change of capacity relative to the maximum change of capacity (that is, at the saturation vapour pressure) and R_H is the relative humidity.

The leakage resistance, R, of the aluminium oxide at 50° C., 60° C. and 70° C. was found to decrease exponentially with increasing water vapour pressure, p. In each case the relationship can be expressed by the equation:

$$R = R_0 \exp(-p/p_0), \qquad (2)$$

where R_0 is the resistance at zero vapour pressure and p_0 is a constant at a given temperature. The accompanying table gives the value of the parameters R_0 and p_0 in (2) for the three temperatures at which these investigations were carried out.

Temperature (° C.)	R_0 (10^7 ohms)	P_0 (mm. mercury)
50	940	13·0
60	93	36·5
70	2·95	118

Preliminary experiments have shown that the capacity element is also sensitive to the vapours of most other substances, and that the magnitude of the effect is related to the saturation vapour pressure and to the dielectric constant of these substances.

It is believed that the effects briefly described above will have many applications in addition to the measurement and control of humidity[2]. Further work is being carried out and a more detailed account will be given elsewhere.

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Effects of Methyl *bis* (beta-Chloroethyl) Amine Hydrochloride on Haploid and Diploid Embryos of *Habrobracon*

X-radiation of the parasitic wasp, *Habrobracon*, has shown that haploids and diploids are differentially radiosensitive. During the larval, prepupal and pupal stages, diploids are more resistant than haploids[1]. During the cleavage stages of the embryo, however, haploids are more resistant than diploids, and immediately after cleavage, haploids and diploids are equally sensitive to X-rays[2]. Some of the mustard compounds are highly mutagenic and cause chromosome breakage[3]. We decided, therefore, to test the effects of the nitrogen mustard, methyl *bis* (beta-chloroethyl) amine hydrochloride on haploid and diploid embryos of *Habrobracon*.

In *Habrobracon*, haploids develop from unfertilized eggs and diploids from fertilized eggs. Haploid cultures are obtained from unmated females, whereas cultures containing both haploid and diploid eggs ('mixed cultures') are obtained from mated females. Normally, about 65 per cent of the eggs from mated females are fertilized and, accordingly, are diploids. In material used in the present report, all haploids develop into males and all diploids into females. Eggs stored in the uterine sacs of the females remain in first meiotic metaphase, and further development does not take place until the eggs are laid[4]. It is therefore easy to obtain embryos of known stages.

Eggs were placed in bags made of lens paper and immersed in solutions of nitrogen mustard for half an hour. The nitrogen mustard solution was made up immediately before use and was kept at *p*H 7 by means of the Teorell buffer. Kolmark and Westergaard[5] have shown that the toxic action of the nitrogen mustard on *Neurospora* is dependent upon *p*H, temperature, concentration, and age of the solution. We have found (unpublished experiments) that these same factors have a marked effect on the hatchability of eggs of *Habrobracon*. Embryos after treatment were washed in a glycine – sodium bicarbonate solution to stop the reaction of the compound and then in distilled water. Afterwards, they were either (*a*) placed in a mineral oil and the incidence of hatchability obtained, or (*b*) placed upon their host (*Ephestia* larva) and the incidence of adult males and females obtained.

Embryos in the cleavage stage were immersed in the nitrogen mustard solution. On the basis of hatchability, the haploid plus diploid cultures (mixed cultures) ($0{\cdot}222 \pm 0{\cdot}014$) were much more affected than were the haploid cultures ($0{\cdot}581 \pm 0{\cdot}017$) (Table 1). Treated embryos from mated females were permitted to develop into adults in order to determine the incidence of haploids (males) and diploids (females). Of the treated embryos, 22 per cent hatched and most of these developed into adults. There is a significant difference in the incidence of females from treated embryos ($0{\cdot}231 \pm 0{\cdot}037$) and the females from controls ($0{\cdot}643 \pm 0{\cdot}020$) (Table 2). These results show that haploid males are much more resistant than diploid females when treated during the cleavage stage. No such differential toxic effect was noted between haploids and diploids treated at later embryonic stages.

Table 1. Hatchability Ratios for Eggs from Mated and Unmated Females treated with Nitrogen Mustard (0·001 per cent) (Eggs treated during the Cleavage Stage)

	From mated females (haploid + diploid)		From unmated females (haploid)	
	No. eggs	Hatchability	No. eggs	Hatchability
Controls	286	$0{\cdot}944 \pm 0{\cdot}014$	217	$0{\cdot}967 \pm 0{\cdot}012$
Treated	878	$0{\cdot}222 \pm 0{\cdot}014$	837	$0{\cdot}581 \pm 0{\cdot}017$

Table 2. Sex Ratios of Adults from Eggs of Mated Females treated with Nitrogen Mustard (0·00075 per cent) (Eggs treated during the Cleavage Stage)

	No. adults	No. ♂♂	No. ♀♀	♀♀
				Total adults
Controls	560	200	360	$0{\cdot}643 \pm 0{\cdot}020$
Treated	130	100	30	$0{\cdot}231 \pm 0{\cdot}037$

When eggs are treated during cleavage, the effects of the nitrogen mustard are apparent prior to hatching, and those that hatch develop normally into adults. Embryos treated in late stages of development, however, even though they may hatch, are arrested in the larval or pupal stages. Haploid embryos that were treated with nitrogen mustard during cleavage were fixed at a stage when somites would normally be present and stained with the Feulgen reagent. Microscopical examination showed that these embryos had been arrested in cleavage. The nuclei and nucleoli were greatly enlarged and mitosis was halted at interphase. The same effects reported here were obtained with X-rays[2].

Differential effects of chemical agents on individuals differing in the number of chromosome sets have been reported by other investigators, although not with the view of correlating their findings with mutagenesis. Fankhauser[6] showed that young pentaploid larvæ of *Triturus viridescens* are more susceptible to chloretone than are diploid larvæ. Briggs[7] treated androgenetic haploids and normal diploids of *Rana pipiens* before or after gastrulation with hexenolactone. He found no differential effects during pre-gastrula development, but treatment after gastrulation showed that haploids were more sensitive. Hexenolactone has been found to be effective in stopping early cleavage'. Smith and Srb[8] have shown that a closely related substance, beta-propiolactone, induces mutations in *Neurospora* and causes chromosomal aberrations in *Vicia faba*.

These results show certain similarities between the effects of methyl *bis* (beta-chloroethyl) amine hydrochloride and of X-rays upon haploids and diploids of *Habrobracon*. Studies in progress on mutagenic and non-mutagenic substances should determine to what extent a differential effect upon haploids and diploids can be used to distinguish substances that are mutagenic and/or cause chromosomal aberrations.

The methyl *bis* (beta-chloroethyl) amine hydrochloride was kindly furnished by Merck and Co., Inc. This work was done under contract No. *AT*(30–1)–953 for the United States Atomic Energy Commission.

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Inhibition Effects in Back-Mutation Tests with Mutants of *Neurospora*

The observation of Grigg[1] that large numbers of conidia of biochemically deficient mutant strains of *Neurospora crassa* strongly inhibit the growth of 'wild-type' conidia when plated on minimal medium containing 0·2 per cent sucrose and 0·4 per cent sorbose led him to question the validity of back-mutation tests. On the other hand, Kølmark and Westergaard[2] have reported that in comparable experiments (using an adenine mutant *W* 40) the substitution of a minimal medium containing 2 per cent glucose completely abolishes the growth inhibition. They suggest that the inhibition of 'wild-type' conidia on sorbose medium results from a removal by the large population of germinating mutant spores of the limited amount of sucrose available; they conclude, therefore, that the growth inhibition has no relation to back-mutation tests as usually conducted.

In connexion with our own studies of chemical mutagenesis[3], we have tested a number of mutant strains to ascertain whether this inhibition phenomenon may affect our tests of mutagenic activity. Biochemically deficient, colonial (70007), macroconidial mutants (induced by mustard-type compounds) were tested for their capacity to inhibit growth of wild-type macroconidia carrying the colonial gene (70007). In reconstruction experiments[1] using a minimal medium containing 1·5 per cent sucrose or 2 per cent glucose, a *p*-aminobenzoic acid mutant *WSC* 4–176 (*paba*) and a leucine mutant *WSC* 7–267 (*leuc*) were found to inhibit the growth of colonial conidia. As shown in the accompanying table, pronounced inhibition occurs under conditions commonly employed in back-mutation tests. Not only was the number of colonies decreased in the presence of the mutant, but the colonies were also smaller and many appeared a day or two later. An inositol mutant 37401 (*inos*), as previously observed[4], showed no inhibitory effect. Comparable experiments have been carried out using, in place of colonial (70007) conidia, *paba*$^+$ and *leuc*$^+$ strains isolated from back-mutation experiments with mustard-type compounds. These strains were also inhibited by mutant conidia (see table). Doubling the concentration of the constituents of the minimal medium did not affect the inhibition of colonial by mutant conidia, but if the minimal medium was supplemented by a mixture of amino-acids and vitamins, inhibition was decreased in the case of the *leuc* mutant.

Effect of Mutant Conidia on Growth of Nutritionally Independent Strains of *Neurospora*

Mutant strain used	No. of mutant conidia (per plate)	Nutritionally independent conidia used	Average inhibition of nutritionally independent conidia (per cent)
paba A	7×10^6	colonial *a*	30
,,	7×10^6	colonial *A*	65
,,	7×10^5	colonial *A*	20
,,	7×10^4	*paba*$^+$ (heterocaryotic)	30
,,	8×10^5	,,	0
,,	7×10^6	*paba*$^+$ (homocaryotic)	70
,,	7×10^5	,,	0
leuc A	8×10^6	colonial *A*	45
,,	8×10^5	*leuc*$^+$ (homocaryotic)	55
inos A	8×10^6	colonial *A*	0

The growth inhibition by different mutant strains can also be demonstrated using a 'half-plate' method. In this technique the suspension of mutant conidia is spread over one-half of the surface of minimal medium in a Petri-dish, allowed to dry for a few hours, and colonial conidia added at a point at the border-line; radial growth is then measured in both directions. The 'giant' colonies grew unilaterally away from the side on which the *paba* or *leuc* mutant had been spread, but no such inhibition was observed with the *inos* mutant. Two cytidine mutants (*WSC* 7–168 and *WSC* 5–25), a cystine mutant (*WSC* 7–303) and a purple adenine mutant (*WSC* 5–298) were found to inhibit colonial growth in varying degrees.

Although both the inhibitory and non-inhibitory types of mutant germinate on minimal medium, experiments indicate that they do not survive equally well in the absence of added supplement. Mutant conidia were plated out in dilute solution (20–200 conidia per plate) on minimal medium, and the compound required by the respective mutant added after a specified number of days. No colonies of the *inos* mutant survived after two days; in contrast, in the case of the mutants which produce growth inhibition, a large proportion of the colonies survived even after six days on minimal medium.

The demonstration of the inhibition of growth of colonial conidia by conidia of certain mutant strains under conditions commonly used in back-mutation experiments reopens the question to what extent this phenomenon affects such results. Grigg suggests the possibility that the back-mutants supposedly induced by the mutagen are already present in the population of untreated conidia but are inhibited either by the large numbers of mutant conidia present or by an intraconidial effect of mutant nuclei. The mutagen, by virtue of its toxicity, would then appear to produce back-mutants simply by killing off inhibiting mutant cells or nuclei. Dilution experiments similar to those described by Grigg[1] were performed with the *paba* and *leuc* mutants. In no case did extra *paba*$^+$ or *leuc*$^+$ colonies appear as a result of plating the mutants at lower concentrations. As a further test, conidia of the mutant strains were treated with a nitrogen mustard, $(C_6H_5CH_2)_2NCH_2CH_2Cl$, which in previous experiments[3] had shown negligible mutagenic activity. In a total of eighteen experiments with *paba* and *leuc* mutants, in which the mortality ranged from 30 to 98 per cent, no induced mutation-rate was recorded. These results provide evidence that, with the particular mutant strains tested, the suggestion of Grigg does not apply. It seems probable that, depending on the nature of the particular mutant employed, the growth inhibition of wild-type by mutant conidia can result in apparent mutation rates which are either higher or lower than the true values.

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Pullman. Sept. 15.

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Auxins and Auxin Precursors in Plants

The principal auxin in higher plants is generally believed to be indoleacetic acid, which is supposed to arise from tryptophane (*a*) *via* indoleiminoacetic acid, indolepyruvic acid and indole acetaldehyde, or (*b*) *via* tryptamine and indole acetaldehyde[1]. The general occurrence of tryptophane in the plant kingdom is well established. Indoleacetic acid has been isolated from seeds; White[2] found tryptamine in *Acacia*; and there is considerable indirect evidence for the occurrence of indole acetaldehyde in pea, pineapple and potato. Synthetic indolepyruvic acid and tryptamine can be converted to indoleacetic acid by certain living plant tissues and enzyme preparations made from them; but the actual function of either of these substances as an intermediary in the biosynthesis of indoleacetic acid from tryptophane has not been proved.

Since certain crude enzyme preparations are able to convert tryptophane and some of the suggested intermediaries to auxin, they may be used as means for detecting naturally occurring intermediaries in the biosynthesis of indoleacetic acid. In experiments carried out at the Department of Botany, University of Chicago (supported in part by a grant from the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago), it was found by Bonde[3] that ether extracts of pea internodes contained no active neutral growth-substance if the extraction was made at 0° C., whereas extracts made at 22° C. contained an abundance of neutral growth-substance, presumably indole acetaldehyde, active in the *Avena* curvature test. It was assumed that this neutral growth-substance was formed during the extraction at the expense of precursors which might possibly be present in the extracts made at 0° C. Various fractions of such extracts, therefore, were treated with fresh coleoptile juice as a source of conversion enzyme. The acid and non-acidic fractions were examined in the *Avena* curvature test. The tests showed that the non-acidic fraction, originally inactive itself, contained an acid growth-substance, presumably indoleacetic acid, after treatment with coleoptile juice. This result indicates the presence in the original extract of a non-acidic precursor of indoleacetic acid. The formation of a neutral growth-substance (indole acetaldehyde) could not be demonstrated, but the possibility of its intermediary formation is not excluded; the aldehyde may become very rapidly converted to the acid.

Similar experiments with the non-acidic fraction of juice exuded from the internode sections during the ether extraction yielded identical results. The acid fraction of the juice was active in the *Avena* test, but its activity increased gradually under the influence of coleoptile juice. These results indicate the presence in pea juice of both a non-acidic and an acid precursor of indoleacetic acid.

Juice exuded from the inner, etiolated leaves of heads of cabbage was treated in the same manner as juice from pea internodes. Again, the non-acidic fraction, originally inactive, yielded an acid growth-substance upon treatment with coleoptile juice. Cabbage juice, however, differed from the juice of pea internodes in that the acid fraction of the juice yielded a neutral growth-substance upon such treatment. These results indicate the presence in cabbage juice of a non-acidic precursor of indoleacetic acid as well as an acid precursor of the neutral growth-substance.

The acid auxin found in all these experiments is undoubtedly indoleacetic acid. The non-acidic precursor found in both ether extract and juice can scarcely be tryptamine because it behaved as a neutral substance, and not as a base, when partitioned between ether and water at either alkaline or acid reaction. The acid precursor present in the juice of pea internodes might be indolepyruvic acid.

Larsen[4] assumed the neutral growth-substance in heads of cabbage to be indole acetaldehyde. The assumption was based on the considerable amount of

indirect evidence for the aldehyde nature of the neutral substance in pea (see also Gordon and Sánchez Nieva[5]), but no actual identification was attempted. Jones *et al.*[6] isolated indole acetonitrile from brussels sprouts. This compound is active in the *Avena* curvature test, the straight-growth test with coleoptile sections, and various other auxin tests. The nitrile is probably also present in heads of cabbage, but further experimentation will now be needed to determine whether or not indole acetaldehyde is present in addition. At present, it is impossible to say whether the above-mentioned acid precursor of a neutral growth-substance in cabbage juice is a precursor of indole acetaldehyde or of indole acetonitrile or both.

Jones *et al.*[6] placed sections of *Avena* coleoptiles in a solution containing 10 mgm. of indole acetonitrile per litre. After 20 hr. the solution contained an amount of acid growth-substance which, if computed as indoleacetic acid, was equivalent to about 1 per cent of the initial amount of nitrile. The amount of unconverted nitrile was not reported. This result, however, does not necessarily indicate that no more than 1 per cent of the nitrile has been converted to acid. As shown by Larsen[7], coleoptile sections inactivate indoleacetic acid very rapidly, and there can be little doubt that indoleacetic acid formed in the experiments by Jones *et al.* would become inactivated to a very considerable extent during the 20-hr. duration of the experiment. The production of indoleacetic acid in their experiments, therefore, may actually have been much higher than 1 per cent of the amount of added nitrile. Coleoptile juice does not inactivate indoleacetic acid and will probably be more suitable than living sections for demonstrating the capacity of *Avena* coleoptiles to convert indole acetonitrile to indoleacetic acid.

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July 30.

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'Diffuse' Centromere, and other Cytological Observations on Two Desmids

Cytological studies of the Desmidiaceæ now in progress in this department have shown that the chromosomes of *Cosmarium botrytis* and *Pleurotænium kallis* have a polycentric or diffuse centromere type of organization, which results in the parallel separation of the chromatids at anaphase (Fig. 1). This type of organization has been previously described in *Spirogyra*[1], and among the higher plants in *Luzula*[2] and *Carex*[3].

The chromosome complement of *Cosmarium botrytis* is $n = 18$ and of *Pleurotænium kallis*, $n = 104$. In the former, the chromosomes at metaphase are loosely joined together, so as to form one or more sinuous threads, while in the latter they are evenly distributed over the equatorial plane of the spindle (Fig. 2). In both, the spindle, like that of *Spirogyra*, is so truncated as to appear sub-rectangular in side view.

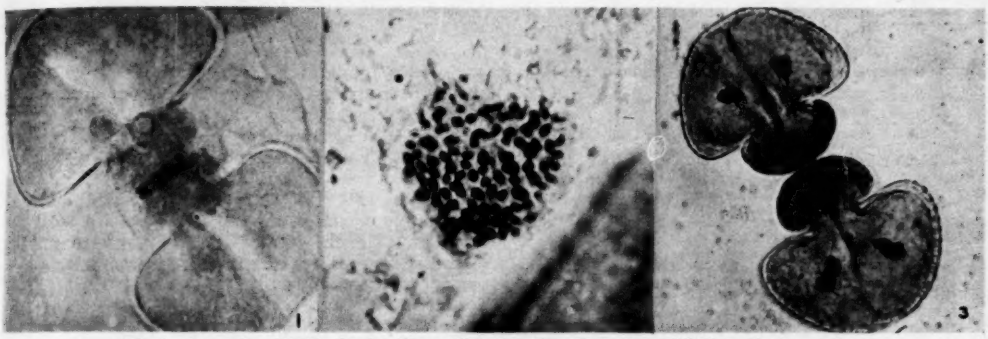

Fig. 1. *Cosmarium botrytis* showing the parallel separation of the chromatids at anaphase. × 1,100
Fig. 2. Polar view of the metaphase plate of *Pleurotænium kallis*. × 1,350
Fig. 3. *Cosmarium botrytis*. Discharge of nuclear material into the protoplasm of the developing semi-cell. Stain: iron aceto-carmine. × 475

The re-establishment of the resting nucleus after division in *Cosmarium botrytis* is peculiar in that the nucleus remains as a plate-like mass at the apex of the developing semi-cell, where it discharges, into the protoplasm of the new semi-cell, material which has a great affinity for iron (this material is presumably ribonucleic acid). So great is this discharge that, with staining, the contents of the semi-cell become obliterated by the intense coloration, which, however, grades off towards the isthmus (Fig. 3). Cells which have been only slightly stained show that at this stage the nucleus begins to migrate to the isthmus, where it is reformed. By this time the new semi-cell is almost fully grown. The re-formation of the resting nucleus at the isthmus goes hand in hand with the progressive loss of affinity for iron of the protoplasm.

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FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, January 26

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. B. H. Farmer: "Problems of Land Use in the Dry Zone of Ceylon".

PHYSICAL SOCIETY, ACOUSTICS GROUP (in Room 4, University College, Malet Place, London, W.C.1), at 5.15 p.m.—Mr. E. Aspinall and Mr. J. Y. Morton: "An Acoustical and Mechanical Impedance Measuring Set, and some Results of Measurements on Human Ears and Mastoids".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "The Relative Merits of Harmonic and Intermodulation Measurements in Assessing Distortion in Audio Equipment" (to be opened by Mr. E. W. Berth-Jones).

Tuesday, January 27

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. D. M. Newitt, F.R.S.: "Experimenting at High Pressures". (Further Lectures on February 3 and 10.)

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. R. Matalon: "Colloid Science and some of its Industrial Applications".* (Further Lectures on February 10, 24 and March 10.)

Wednesday, January 28

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Dr. D. T. Germain-Jones: "Geophysics—its Problems and Trends".*

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. A. F. B. Young: "Some Researches on Circuit-Breaking by means of High-Voltage Circuit-Breakers, with special reference to Current-Chopping".

ILLUMINATING ENGINEERING SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Dr. E. D. Adrian, O.M., Pres.R.S.: "The Nervous Reactions of the Retina" (Trotter–Paterson Memorial Lecture).

SOCIETY OF CHEMICAL INDUSTRY, NUTRITION PANEL of the FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Dr. G. A. C. Herklots and Prof. J. Yudkin: "Food and the Future", 2: "Some Present-day Methods of Attack on the Problems of Food Production".

Thursday, January 29

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 10 a.m.—Discussion on "*V*-Particles and Heavy Mesons" (to be opened by Prof. C. F. Powell, F.R.S.).

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "Problems of Distribution of Animals and Plants in Africa".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. D. M. Ross: "Scholarship and Practice in the History of Biology".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Dr. S. R. Nockolds: "Trace Elements in the Earth". (Further Lectures on February 5 and 12.)

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. John Wilks: "The Influence of R. W. Chambers on the Development of University Libraries" (Chambers Memorial Lecture).*

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 6 p.m.—Major P. Litherland Teed: "Titanium—a Survey".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, MICROCHEMISTRY GROUP (at the Sir John Cass College, Jewry Street, London, E.C.3), at 7 p.m.—Annual General Meeting; Dr. Cecil L. Wilson: "Microchemistry, an Appraisal".

Friday, January 30

INSTITUTION OF MECHANICAL ENGINEERS (joint meeting with the STEAM GROUP, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. H. Hillier: "Scale Formation in Sea-Water Distilling Plants and its Prevention".

ROYAL INSTITUTE OF PHILOSOPHY (at University Hall, 14 Gordon Square London, W.C.1), at 5.30 p.m.—Mr. D. A. Rees: "Greek Views of Nature and Mind".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (in the Mason Theatre, The University, Edmund Street, Birmingham), at 6.30 p.m.—Discussion on "Chromatography".

UNIVERSITY OF LONDON (at Westfield College, Kidderpore Avenue, Hampstead, London, N.W.3), at 7.45 p.m.—Very Rev. H. A. Jones: "The Scientist's Universe and the Christian's Faith".* (Further Lectures on February 13 and 20.)

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Harold Spencer Jones, F.R.S.: "The Mountains of the Moon".

Saturday, January 31

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Miss Winifred M. A. Brooke: "The Bolivian Andes and its People To-day".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

EXPERIMENTAL OFFICER AT THE FUEL RESEARCH STATION, Greenwich—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.754/52A (January 31).

SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent, in chemistry) with sound knowledge of electrochemistry and electrodeposition of metals, at a Ministry of Supply Establishment, Aldermaston—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.817/52A (January 31).

ASSISTANT (with a university degree, preferably in economics or mathematics, and experience in operational research or similar work) IN THE OPERATIONAL RESEARCH SECTION, Generation Operation Branch, headquarters Bankside—The Director of Establishments, British Electricity Authority, British Electricity House, Winsley Street, London, W.1, quoting Ref. AE.302 (February 2).

HEAD OF THE DEPARTMENT OF MECHANICAL AND ELECTRICAL ENGINEERING—The Principal, Wigan and District Mining and Technical College, Wigan (February 2).

METEOROLOGICAL OFFICERS (with an honours university degree covering physics, mathematical physics or mathematics, or a university degree in meteorology, or an academic qualification equivalent to either) in the Department of Industry and Commerce, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (February 3).

SCIENTIFIC OFFICER (with a good honours degree, an interest in biological problems and, preferably, some research experience) IN THE CHEMISTRY DEPARTMENT, to take part initially in researches on the chemistry of the milk proteins and enzymes—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 53/2 (February 7).

BIOCHEMIST (principal or senior grade) IN THE GROUP PATHOLOGICAL DEPARTMENT—The Secretary, South Worcestershire Hospital Management Committee, Royal Infirmary, Worcester (February 9).

SCIENTISTS (with honours degree or equivalent and a good knowledge of at least one of the following subjects: physical metallurgy, engineering metallurgy, including knowledge of machinery, tool materials, hard metals, etc., physical chemistry, corrosion) at the Central Research Establishment, Isleworth, Middlesex—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/578 (February 9).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF CIVIL ENGINEERING—The Registrar, The University, Liverpool (February 11).

RESEARCH ASSISTANT IN THE DEPARTMENT OF ANATOMY, for work mainly on central nervous system—The Secretary, University College, Gower Street, London, W.C.1 (February 13).

BRITISH COKE RESEARCH ASSOCIATION FELLOWSHIP tenable in the Department of Coal Gas and Fuel Industries, for research at post-graduate standard on a subject connected with the coke industry—The Registrar, The University, Leeds 2 (February 14).

LECTURER IN PURE MATHEMATICS (preferably qualified in algebra and geometry)—The Registrar, University College, Singleton Park, Swansea (February 14).

RESEARCH OFFICER (with a University honours degree in science with botany and chemistry as major subject or in agricultural science or equivalent qualifications) TO THE DIVISION OF PLANT INDUSTRY, Plant and Soils Laboratory, Brisbane, to undertake studies on the factors limiting legume establishment in sub-tropical areas of southern Queensland—The Chief Scientific Liaison Officer, Australia Scientific Liaison Office, Africa House, Kingsway, London, W.C.1, quoting No. 4119 (February 14).

RUTHERFORD SCHOLARSHIP for research in any branch of the natural sciences—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (February 15).

UNIVERSITY DEMONSTRATOR IN ZOOLOGY—Dr. A. S. Watt, Department of Botany, Downing Street, Cambridge (February 15).

SENIOR AGRICULTURAL ECONOMIST, and an ASSISTANT AGRICULTURAL ECONOMIST—The Registrar, King's College, Newcastle-upon-Tyne (February 16).

SENIOR LECTURER IN ZOOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 28).

PHYSICIST to Dundee Royal Infirmary, associated with a LECTURESHIP IN THE DEPARTMENT OF PHYSICS in University College, Dundee—The Medical Superintendent, Royal Infirmary, Dundee (March 1).

SENIOR LECTURER IN MECHANICAL ENGINEERING at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 13).

LECTURER IN CIVIL ENGINEERING with particular interest in hydraulics—The Secretary, Queen's University, Belfast (March 15).

SENIOR LECTURER or LECTURER IN PHYSICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 15).

CARDEN RESEARCH FELLOW (graduate in medicine, science or veterinary science) for research into the cause and cure of cancer, at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 31).

ASSOCIATE PROFESSOR OF PATHOLOGY and ASSOCIATE PROVINCIAL PATHOLOGIST for the Province of Nova Scotia (combined position)—Dr. N. G. B. McLetchie, Provincial Pathologist, Dalhousie Medical School, Halifax, Nova Scotia, Canada.

CHIEF SCIENTIFIC AND ADMINISTRATIVE ASSISTANT (with a degree in botany or agriculture, or equivalent qualification) in the Official Seed Testing Station—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

SUPERINTENDENT IN CHARGE OF THE PLANT ENGINEERING DIVISION—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Plant Engineering".